SOVIET / RUSSIAN AIRCRAFT WEAPONS

Since World War Two

Yefim Gordon

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MIDLAND
An imprint of
Ian Allan Publishing

Soviet/Russian Aircraft Weapons

Original translation by Dmitriy Komissarov
ISBN 1 85780 188 1

Published by Midland Publishing
4 Watling Drive, Hinckley, LE10 3EY, England
Tel: 01455 254 490 Fax: 01455 254 495
E-mail: midlandbooks@compuserve.com
www.midlandcountiessuperstore.com

Midland Publishing is an imprint of
Ian Allan Publishing Ltd

Worldwide distribution (except North America):
Midland Counties Publications
4 Watling Drive, Hinckley, LE10 3EY, England
Telephone: 01455 254 450 Fax: 01455 233 737
E-mail: midlandbooks@compuserve.com
www.midlandcountiessuperstore.com

North American trade distribution:
Specialty Press Publishers & Wholesalers Inc.
39966 Grand Avenue, North Branch, MN 55056, USA
Tel: 651 277 1400 Fax: 651 277 1203
Toll free telephone: 800 895 4585
www.specialtypress.com

Design concept and layout by
Polygon Press Ltd (Moscow, Russia)
Line drawings by Oleg Put'makov, Polygon Press
and from Yefim Gordon archive

This book is illustrated with photos by Yefim Gordon, Victor Drushlyakov, Vyacheslav Martyniuk, Sergey Skrynnikov, Peter Davison, Marcus Fülber, Waclaw Holys, Martin Novak, RSK MiG, AVPK Sukhoi, Tupolev JSC, MKB Radga, Zvezda-Strela, GMKB Vympel, NPO Bazal't, ITAR-TASS, as well as from *Jane's All the World's Aircraft*, *M-Hobby* magazine, *Lotnictwo* magazine, the archives of Yefim Gordon and the Russian Aviation Research Trust.

Printed in England bylan Allan Printing Ltd
Riverdene Business Park, Molesey Road,
Hersham, Surrey, KT12 4RG

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Below: A Kh-29T air-to-surface missile belches terrific flames with shock diamonds as it streaks away a couple of seconds after being launched by the Su-30KN prototype, '302 Blue' (c/n 79871010302), during the latter's state acceptance trials.

INTRODUCTION

In recent years Midland Publishing and several other Western publishers have released quite a large number of books charting the development history of various Soviet/Russian aircraft – primarily military types, of course. However, a monograph devoted to a specific combat aircraft leaves no room for a detailed description of the means it uses to complete its objective, namely the weapons which the aircraft can carry. The following reference book is an attempt at making up for this unfortunate omission.

Before embarking on a detailed analysis of the post-war Soviet aircraft weapons and their specifications it makes sense to take a brief look at the beginnings – the history of early pilotless combat aircraft development in the Soviet Union which began in the late 1930s.

The development and operational use of various kinds of guided weapons during the Second World War was largely made possible by the pre-war research and development work – not only in Germany (which was the first to use such weapons) but also in the USA, Great Britain and the Soviet Union. In the latter nation, work in this field somehow continued in spite of the repressions that claimed the lives (or at least the freedom and ability to work) of many leading specialists at the Jet Propulsion Research Institute (RNII; see note on its history in Chapter 3) which specialised in rocket weapons development – including guided missiles.

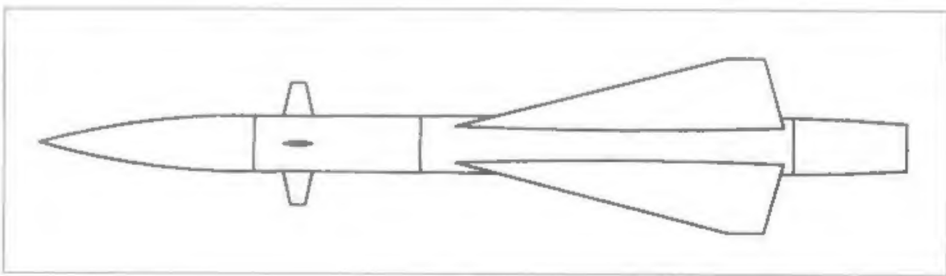
The period of 1937-1940 saw several experimental remote-controlled – or, in the Soviet terminology of the time, telemechanical – aircraft (TMS, ***telemekhanicheskiy samolyot***) and gliding torpedoes being developed in the USSR. The first prototype of the TB-3 ***Bomba*** (Bomb) radio-controlled aircraft developed by R. G. Chachikian – a 'flying bomb' version of the obsolescent Tupolev TB-3 (ANT-6) heavy bomber – successfully completed its state acceptance trials in early 1941. Concurrently two other 'flying bombs' derived by Chachikian from the TB-3 and the Tupolev SB (ANT-40) fast bomber were undergoing checkout tests at the Flight Research Institute (LII – ***Lyotno-issledovatel'skiy institoot***) in Ramenskoye east of Moscow as their remote control systems were being calibrated. (The LII was a test and research establishment within the framework of the People's Commissariat of Aircraft Industry (NKAP – ***Narodnyy komissariaht aviatsionnoy promyshlennosti***), which became the Ministry of Aircraft Industry (MAP – ***Ministerstvo aviatsionnoy promyshlennosti***) in 1947.) At about the same time a remote-controlled SB developed by engineer Neopalimyy and a remote-controlled Polikarpov UT-2 primary trainer developed by engineer Nikol'skiy were being tested in Leningrad, with state acceptance trials slated for July-August 1941.

Plans were in hand to launch production of telemechanical target drones and bombers, but these plans were foiled by the outbreak of the Great Patriotic War on 22nd June 1941. The advance of the Wehrmacht and the danger that Leningrad could be besieged by the Germans (which it was, and the siege lasted 900 days) compelled the customers – that is, the Red Army Air Force and the Soviet Navy – to put the manufacture of six telemechanical aircraft prototypes at plant No.379 on hold, the remote control equipment being evacuated to Kazan'.

The two remote-controlled TB-3s which had already passed their trials were handed over to the Red Army Air Force Research Institute (NII VVS KA – ***Naoochno-issledovatel'skiy institoot Voyenno-vozdooshnykh seel Krasnoy armii***) for use in actual combat, but the institute was not in a hurry to use them. (The institute was later renamed GK NII VVS – ***Gosoodarstvennyy krasnoznamyonnyy Naoochno-issledovatel'skiy institoot Voyenno-vozdooshnykh seel*** – State Red Banner Air Force Research Institute, that is, awarded the Order of the Red Banner.) The Soviet military showed no particular interest in the new type of weapons. The only occasion when a remote-controlled TB-3 'flying bomb' was used in action in January 1942 ended in failure. The objective was a railway junction in the town of Vyaz'ma west of Moscow; the TB-3 was controlled from a suitably equipped Il'yushin DB-3 bomber and escorted by fighters. Near the target, however, the formation came under anti-aircraft artillery fire. A shell bursting near the DB-3 ripped away a piece of fuselage skin, destroying the guidance antenna and rendering the 'flying bomb' uncontrollable; the TB-3 disappeared into clouds and flew on until it ran out of fuel and crashed.

Still, the Soviet military did not give up on remote-controlled aerial weapons systems altogether at this stage, and we will come back to this subject a little later.

After the Second World War the world political situation was not so sunny for the Soviet Union, to say the least. The one-time allies in the fight against Nazism had turned 'potential adversaries'; military technologies were making rapid progress on both sides of the Iron Curtain, and the Cold War that started soon after the end of the hostilities quickly escalated into an arms race. Now the Soviet military were compelled to consider defensive weapons systems as well as offensive ones (or 'weapons of retaliation', as they liked to put it) – especially since the USA now had a large fleet of nuclear-capable strategic bombers. New guided air-to-surface, surface-to-air and air-to-air missiles had to be developed; this turned out to be a major task and more than a decade passed



A provisional drawing of the SNARS-250 homing air-to-air missile – the first of its kind to be developed in the Soviet Union. The radar-homing version is shown here.

Left: A number of V1 (Fieseler Fi 103) 'buzz bombs' fell into Soviet hands at the end of the Great Patriotic War; one of them is shown here.

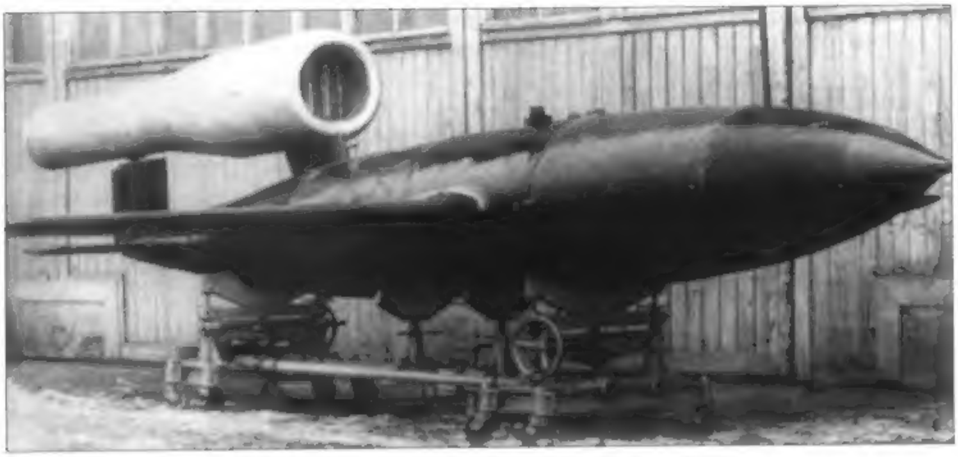
Below left: The V1 was copied in the Soviet Union (as were some other German military hardware items), receiving the designation 10Kh.

before the first operational missiles were tested and fielded. The best development and production enterprises of the aviation and electronics industries were enlisted for the task; other branches of the Soviet economy made a major contribution, too.

In 1946-49 a team led by E. N. Kasherininov at the NII-2 research institute conducted research with a view to developing air-to-air missiles (AAMs) to be used against bombers, assessing various target approach and missile guidance techniques and ways of using them in practice. In so doing a group headed by I. A. Boguslavskiy developed the theory of a crossing engagement of an oncoming target.

Both beam-riding (radio command guidance) and homing versions of the missile were considered; so was a spin-stabilised version of the AAM. The missile was to be powered by a solid-fuel rocket motor. Designated RSS (*reaktivnyy **s**amonavo**dya**shchiysya sna**ryad*** – jet-propelled homing missile), the weapon never reached the hardware stage; only a full-scale mock-up was manufactured, undergoing stability tests at LII and wind tunnel tests at the Central Aero- & Hydrodynamics Institute named after Nikolay Ye. Zhukovskiy (TsAGI – *Tsen**trahl'**nyy aero- i **ghid**rodina**mich**eskiy insti**toot***).

A different homing AAM designated SNARS-250 (***s**amonavo**dya**shchiysya aviatsi**onn**yy reak**tiv**nyy sna**ryad*** – homing air-launched missile of 250 mm (9.84 in) calibre) was developed at MAP plant No.293 under the guidance of the plant's Chief Designer Matus Ruvimovich Bisnovat, with engineer Popov as project chief. Designed for use against heavy bombers, the SNARS-250 had infra-red homing and semi-active radar homing (SARH) versions; a television-guided homing version was also considered. No specific fighter type was chosen to carry the missile. In fact, the original intention was to fit the SNARS-250 to tactical bombers – the piston-engined Tupolev Tu-2 and then the twin-turbojet Il'yushin IL-28; the Mikoyan/Gurevich MiG-15 and MiG-17 fighters were ruled out, however, due to the missile's considerable weight.



Above left: Another example of the 10Kh on a ground handling dolly, showing well the grid in the pulse-jet's air intake.

Left: A 10Kh on its launch trolley with two rocket-assisted take-off (RATO) boosters attached.

Right: A 10Kh missile installed on the ramp and ready for launch.

Below right and bottom right: Two views of a 10Kh as it blasts off in a sheet of flame.

By the beginning of 1952 the design team had completed the advanced development project of the SNARS-250, developing separately the missile's airframe, autopilot, and IR and radar seeker heads. The first launches of the missile in guided mode from a Tu-2 weapons testbed took place in 1952; four further launches in which the missile was controlled by the autopilot only (including two successful ones) were made in May-July of that year. During August-October 1952 the heat-seeking version was test-fired from the Mikoyan/Gurevich I-320 experimental two-seat heavy fighter. Four launches were made against a tracer suspended from a tethered balloon and two more with the 'heat signature of the Moon' (!) as the target; curiously, all four missiles fired at the tracer missed the mark, while one of the two attempts to 'shoot down the Moon' gave satisfactory results. Four test launches of the SARH version followed in October and November 1952; three out of four ended in failure.

Despite the need for an air-to-air missile, the development of the SNARS-250 was not completed, probably because the Soviet government was displeased with the scant success achieved during the tests. On 19th February 1953 the Council of Ministers issued directive No.531-271 ordering the cancellation of the missile and transferring the design team (together with plant No.293 where it as located) to the Special Bureau No.1 (SB-1 – *spetsiahl'noye byuro*), a design office in the Ministry of Armament framework, as an affiliate tasked with rocket development.

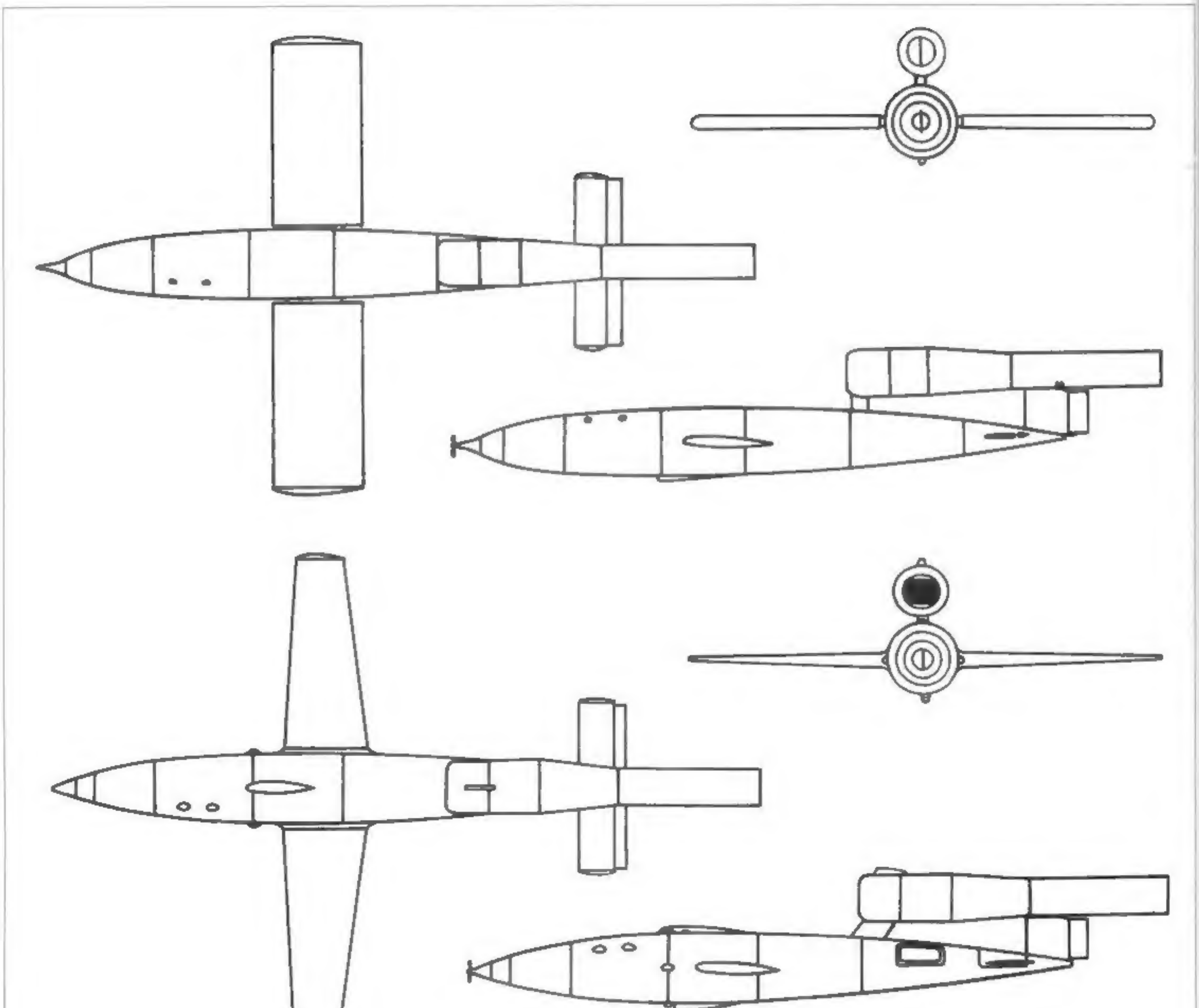
Finding themselves 'laid off', the design staff of the former MAP factory No.293 wrote an official letter to the government, pleading the advisability of continuing the guided missile development programmes which the plant's design bureau had been tasked with before the reorganisation. However, they were 'voted down' by Minister of Aircraft Industry Mikhail V. Khrunichev and Minister of Defence Industry Dmitriy F. Ustinov who, after considering the appeal, reported to Council of Ministers Chairman (= Prime Minister) Nikolay A. Boolganin that further work on missiles was inexpedient. One of the reasons for the SNARS-250's cancellation was that no workable air-to-air missile guidance systems existed in the USSR at the moment.

Guided strike weapons fared somewhat better in the immediate post-war years. To realise how seriously this class of weapons was taken in the Soviet Union we have to go back in time to the Second World War.

On the night of 13th June 1944 London was attacked with a new type of weapons – 'buzz bombs' (thus nicknamed because of the characteristic sound emitted by their pulse-jet engines; the term 'cruise missile' had not yet been coined). A fortnight later, on 25th June, the German radio service broadcast information on this new weapon called V1; the V stood for *Vergeltungswaffe* (weapon of retribution). Nothing of the kind existed in the other belligerent nations at the time; yet, while having a certain psychological impact on the enemy, the V1 played no significant role in the war, being handicapped by relatively short range, a relatively low speed, poor reliability and the poor mobility of its bulky launch ramps.

Eighteen months after the first V1 attack on London the NKAP top brass (and probably the Soviet military leaders as well) did an 'about face' on their attitude to guided weapons. The aforementioned engineers Nikol'skiy and Chachikian wrote to the Soviet government; this letter prompted the preparation of a draft directive by the State Defence Committee (GKO – *Gosoodarstvennyy komitet oborony*) ordering the establishment of the OKB-100 design bureau within the MAP system with a prototype construction shop and flight test facility based on the (former) plant No.23 in Leningrad. The new enterprise was tasked with developing and building radio-controlled and unguided gliding torpedoes and radio-controlled guided bombs. At about the same time the task of developing an indigenous equivalent of the German 'buzz bomb' was assigned to the Central Aero Engine Institute (TsIAM – *Tsentrahl'nyy institoot aviatsionnovo motorostroyeniya*).

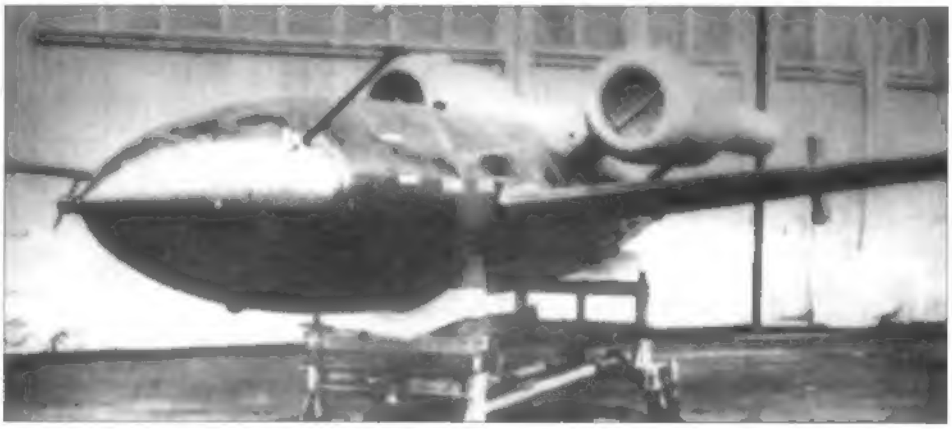
Work on pulse-jet engines at TsIAM had proceeded since 1942 under the guidance of Vladimir Nikolayevich Chelomey. It took him two years to build and test the first workable Soviet pulse-jet. When the Soviet government learned of the missile attack on London, Aleksey I. Shakhoorin (the then People's Commissar of Aircraft Industry), Air Marshal A. A. Novikov (the then Commander-in-Chief of the Red Army Air Force) and



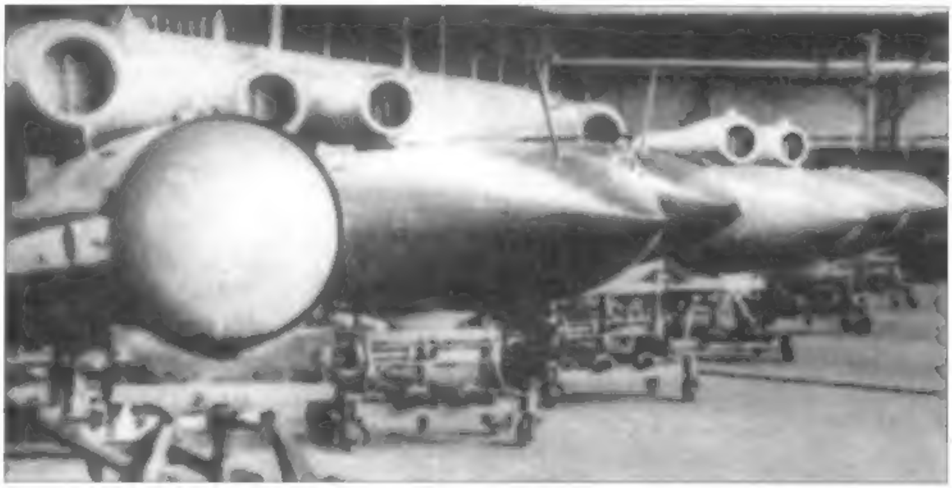
Opposite page, top to bottom: Three-views of the 10Kh, the 14Kh and the 16Kh (the latter as actually built with two D-3 engines).

This page, above: One of the Petlyakov Pe-8 bombers used as 'mother ships' for 10Kh missiles during the trials programme in Dzhizak. This example is a Pe-8 4M-82 powered by Shvetsov M-82 fourteen-cylinder radial engines. Note how low the missile sits above the ground; it is attached to the bomber's fuselage by struts.

Right: The prototype of the 16Kh missile on a ground handling dolly, showing the outward-canted engine pylons and the twin tails. Note also the long pitot head canted to port and the propeller-like vane of the wind-driven generator.



Below right: The 16Kh production line at plant No.51. The missile nearest to the camera is not yet fitted with a warhead, showing the forward bulkhead of the fuel tank and the tubular wing spar carry-through structure.



V. N. Chelomey were summoned to the Kremlin for a GKO briefing and tasked with developing new pilotless aerial weapons systems. The appropriate GKO directive appeared soon afterwards.

The advanced development project of Chelomey's winged missile powered by a D-3 pulse-jet and designated 10Kh was completed in the late summer of 1944. On 19th September of that year V. N. Chelomey was appointed Chief Designer and Director of NKAP plant No.51 – the former prototype construction shop of the late 'Fighter King' Nikolay N. Polikarpov.

Development of the 10Kh was accelerated by the delivery of incomplete V1 'buzz bombs' (or their wreckage) from Great Britain and Poland; yet, while bearing a strong resemblance to the V1, the 10Kh was *not* a direct copy of it. For instance, to speed up the production entry of the Soviet missile's AP-4 autopilot the specialised OKB-1 design bureau under V. M. Sorkin made maximum use of off-the-shelf components from production Soviet aircraft instruments. By early 1945 the first prototype 10Kh had been completed and the D-3 engine had passed official bench tests at TsIAM. The first production missile left the assembly line as early as 5th February 1945; seventeen of the nineteen missiles manufactured by plant No.51 were cleared for flight tests, the remaining two being retained by the plant as pattern samples.

Three Petlyakov Pe-8 long-range bombers and two Yermolayev Yer-2 long-range bombers were fitted out with racks for carrying and launching the 10Kh missile. The smaller and cheaper Yer-2 was considered a better alternative, but the Charomskiy ACh-30B diesels of the first Yer-2 involved suffered from the high ambient temperatures of Central Asia where the test range was; the shortfall in engine power was so severe that the bomber could not become airborne with the missile in place. Eventually the engines went unserviceable altogether and from then on only the Pe-8s were used in the tests at that location; the other Yer-2 was operated in the cooler climate of the Moscow Region.

Manufacturer's flight tests of the 10Kh began on 20th March 1945; the test facility was located at Dzhizak in the middle of nowhere – a vast expanse of Uzbek badlands called *Golodnaya step'* (The Hungry Steppe). Stage 1 involved checking the operation of the missile rack's release mechanism, the missile's separation and the operation of the missile's engine and sys-

Top and above: A black-painted 16Kh missile suspended under a Tu-2LL testbed for a test drop. The aircraft was converted from a Tu-2S with three-bladed propellers. Note the engine ignition system cables running from the aircraft's fuselage to the missile's engine nacelles.

tems at the moment of launch. The separation took place at 2,000 m (6,560 ft), the missile losing 100 to 200 m (330-660 ft) of altitude before it stabilised in level flight; after that the 10Kh followed the preset heading which had been entered into the autopilot on the ground. This was theory; in practice, however, only six of the 22 missiles dropped during the trials flew as they should – the others dived straight into the ground.

The flight tests of the 10Kh were completed on 25th July 1945. A total of 66 missiles was dropped, of which 44 managed the transition to autonomous flight; the range target was met in 24 cases and the required heading was maintained in 20 cases.

Tests of a remote-controlled gliding bomb began at the same location (in Dzhizak) in July 1945. Created by the above-mentioned OKB-1 (which was responsible for autopilot design), the bomb was a derivative of the 10Kh missile and was intended for use against large factories or shore facilities well protected by anti-aircraft artillery. The bomb lacked the 10Kh's engine and some of the autopilot components; the space normally occupied by fuel tankage was used to accommodate a greater explosive charge, which now weighed 1,500 kg (3,310 lb). In order to retain acceptable static stability around all three axes the vertical fin, which had doubled as the engine pylon was augmented by two stabiliser endplates of rectangular planform. The dissolution of the 'badlands task force' brought an end to the tests of the gliding bomb as well.

Right: The Tu-2-cum-16Kh combination in flight.

Below right: The 16Kh falls away from the Tu-2, losing a considerable amount of altitude before stabilising in level flight. Note the flames belching from the engine jetpipes.

In the spring of 1945 NKAP plant No.125 joined forces with other plants to launch production of the 10Kh in accordance with the manufacturing documents supplied by Chelomey's plant No.51. A total of 300 had been built before production was halted due to the end of the hostilities.

In the meantime the Chelomey OKB brought out three models of more powerful pulse-jets based on the D-3; these were the D-5 rated at 420-440 kgp (925-970 lbst), the 600-kgp (1,320-lbst) D-6 and the 900-kgp (1,980-lbst) D-7. The D-5 delivered 425 kgp (937 lbst) during bench tests in November 1945. Back in 1944 Chelomey had begun design work on the 14Kh winged missile powered by this engine. The greater engine thrust and the more aerodynamically refined fuselage were expected to give this weapon a 130-150 km/h (80-93 mph) higher cruising speed as compared to the 10Kh; the new engine's higher weight was offset by a weight saving thanks to changes in the wing design (the wings were smaller, featuring pronounced taper).

Teaming up with plant No.456, the Chelomey OKB's experimental shop manufactured a batch of twenty 14Kh missiles in 1946. Ten of them underwent flight tests at a target range between 1st and 29th July 1948, a Pe-8 bomber acting as the launch platform. Six of these missiles featured standard rectangular wings, while the other four featured reinforced wings of trapezoidal planform; the wings were of wooden construction in both cases. The trials showed that the 14Kh met the specifications; the trapezoidal-wing version attained a speed of 825 km/h (512 mph) or even higher on a 100-km (62-mile) stretch, exceeding the target figure by 10%. On the other hand, the wooden wings were not strong enough; several wing failures were experienced and the structure needed to be reinforced before the missile could enter service.

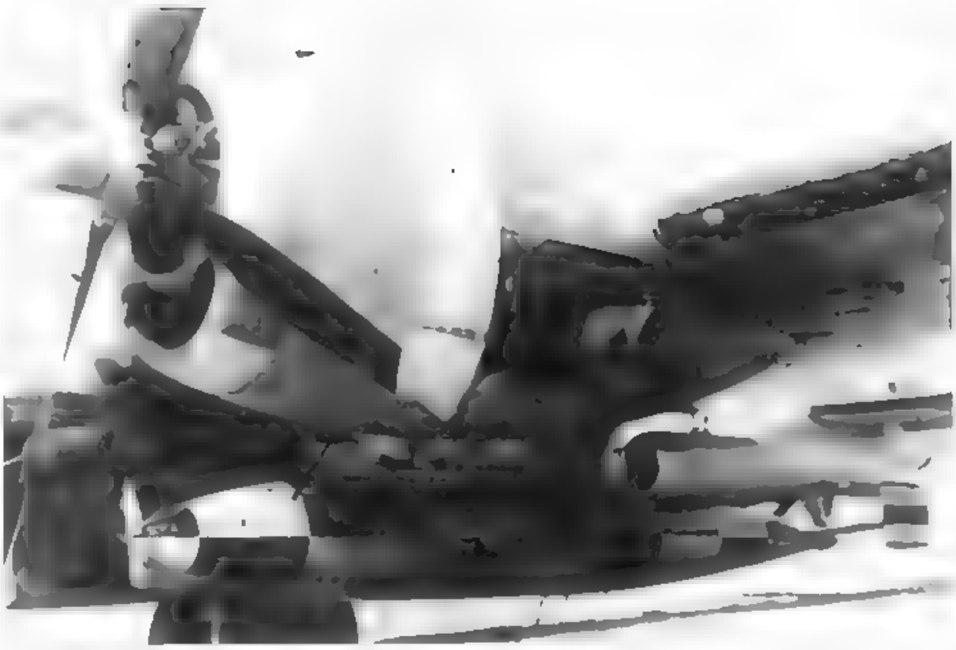
The D-6 passed its official manufacturer's tests in October 1946 with good results. Two months later it bettered the specified thrust figure by 110 kgp (240 lbst) when run on a bench during state acceptance trials. This allowed plant No.51 to develop a projected winged missile of 7,000 kg (15,430 lb) calibre powered by two D-6 engines in 1946.

The year of 1947 saw the development of the 14KhK1 winged missile; it was powered by just a single D-6 but featured wings of greater area. This weapon was to be the first stage in the effort to develop a cruise missile under the *Kometa-3* (Comet-3) programme. However, in the first half of 1948 the abovementioned SB-1 design bureau, which was the main 'contractor' under this programme, came up with a new specification; the missile was to be based on the airframe of the first Soviet jet fighter, the MiG-9.

Meanwhile, back in 1945 the Chelomey OKB had completed the advanced development project of the 16Kh winged missile. At first this was basically the airframe of the 10Kh mated to a D-6 engine; later, however, the project was significantly revised to feature two D-3 engines on outward-canted pylons. The Tu-2 bomber was chosen as the delivery vehicle.

In early 1947 plant No.51 (the Chelomey OKB) was tasked with developing a whole series of winged missiles: the air-launched

Right: A 16Kh suspended beneath a Pe-8 at another stage of the trials. This view illustrates well the design of the missile attachment rack.



A black and white chequered inert 16Kh under the wing of a Tu-4 weapons testbed; this one has small vertical tails Note the design of the pylon installed between the inner and outer engine.

16Kh, the naval 15Kh and 17Kh to be launched from surface ships, and the 18Kh Very soon, however, the government had to curb its appetite, limiting the order to the revised 16KhA *Priboy* (Surf) missile and the 10KhM target drone (M = ***mishen'*** target)

The Priboy missile featuring a programmable autonomous control system underwent joint manufacturer's/Air Force trials in August 1952; this time the delivery vehicle was a modified Tu-4 heavy bomber which could carry two missiles under the wings Generally the missile met the performance target, but operational reliability and targeting accuracy left something to be desired, which is why the Priboy was not recommended for production and service. Still, the Air Force proposed testing a pre-production batch of 60 such missiles in 1953, providing measures to improve reliability and accuracy had been incorporated

However, the government had different ideas. On 19th February 1953 all work on Chelomey's missiles (as well as on Bisnovat's missiles) was terminated without cause, discussion of technical matters or even warning; this was the handiwork of Lavrentiy P. Beria, the notorious Minister of the Interior who also exercised control over weapons technology development programmes (and who had his own interest in the matter, namely to advance his own son's career). Plant No 51 and its OKB were closed down, all personnel and equipment being transferred to Artyom I. Mikoyan's OKB-155 which set up a branch office at the newly appropriated premises. In a letter to Council of Ministers Chairman Gheorgiy M Malenkov the justifiably angry Vladimir N Chelomey cited his being a competitor to Mikoyan and Sergey L. Beria (the minister's son, head of the Ministry of Armament's KB-1 previously known as SB-1), who were jointly developing cruise missiles similar to his, as the main reason for this wanton liquidation

Yet Chelomey was soon avenged to a certain degree After Iosif V Stalin's death in May 1953 the situation in the Soviet Union changed and the tables were turned on those who were responsible for the repressions of the past years. Lavrentiy P Beria and Sergey L. Beria were both arrested (Beria Sr. was later shot), Mikoyan survived but OKB-155 lost the former plant No 51 which was transferred to Pavel O Sukhoi's OKB-1 (itself a victim of such political games) on 26th October 1953, becoming the State Union Plant No 51 on 15th January 1954 (this day is regarded as the date when the Sukhoi OKB was reborn). After several more appeals to Malenkov, Chelomey finally managed to receive a go-ahead to resume his work in 1954, heading a Special Design Group which was transformed into OKB-52 a year later

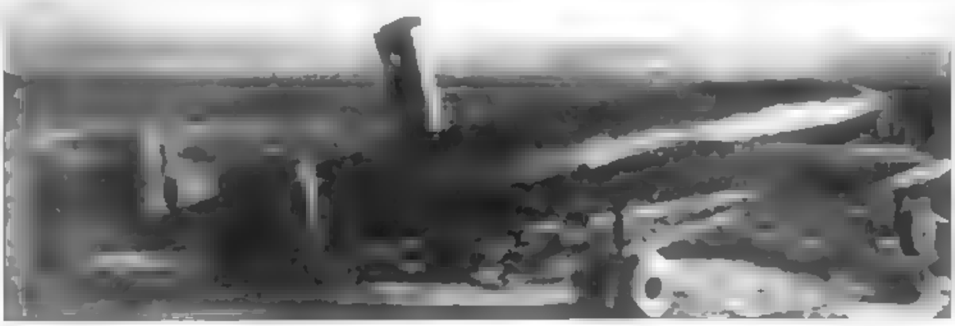
Thus, by the mid-1950s, in spite of various misadventures, Soviet weapons designers had accumulated quite a wealth of experience in the design and testing of guided aircraft weapons. This was the time when new guided missiles, unguided rockets and new types of bombs really started entering production and Soviet Air Force service. Missile-armed interceptors and long-range bombers carrying cruise missiles began making an appearance on Soviet airbases in the late 1950s. On the whole, Soviet air-launched missile systems were quite a match for their US counterparts, any inferiority on the part of the Soviet weapons was minor and was due to the less sophisticated electronic components of the guidance systems

The four chapters that follow give an overview of the principal types of post-war Soviet guided and unguided aircraft weapons. Only the principal types are described here, as unfortunately space limitations make a more detailed design and development history description impossible This book does not purport to be the 'ultimate authority' on Soviet aircraft weapons; for instance, aircraft cannons and machine-guns are not described here

In writing this book the author relied on books and magazines published in Russia over the last ten years

Acknowledgements

The author wishes to express his sincere thanks to his colleagues without whose assistance the book would never have been completed, namely Viktor Kudryavtsev, who provided text information on Soviet aircraft weapons, and Oleg Put'makov who made the excellent line drawings in this book As usual, thanks also go to Dmitriy Komissarov for the excellent translation, which was quite a tough job



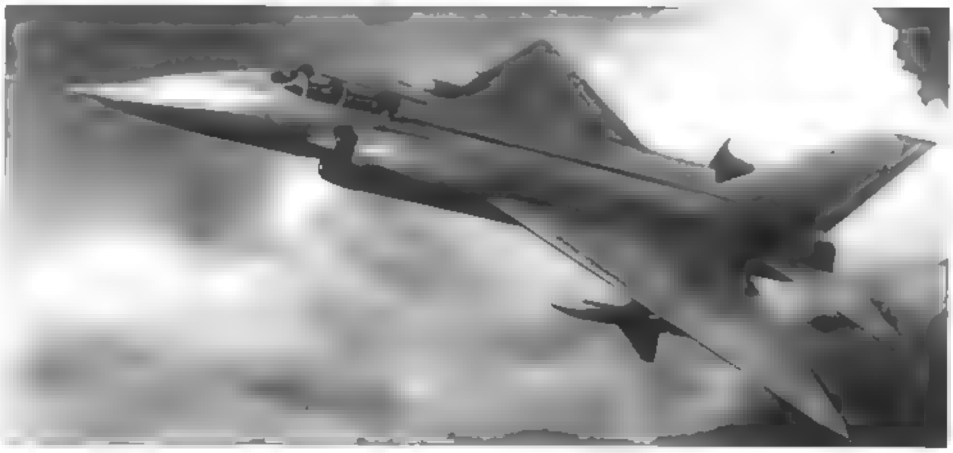
A guided bomb based on the airframe of the 10Kh missile Note the twin tails and the extended centre fin The object in the centre which looks like a smokestack in not part of the bomb.

'SHOOT 'EM DOWN' THE AIR-TO-AIR MISSLES

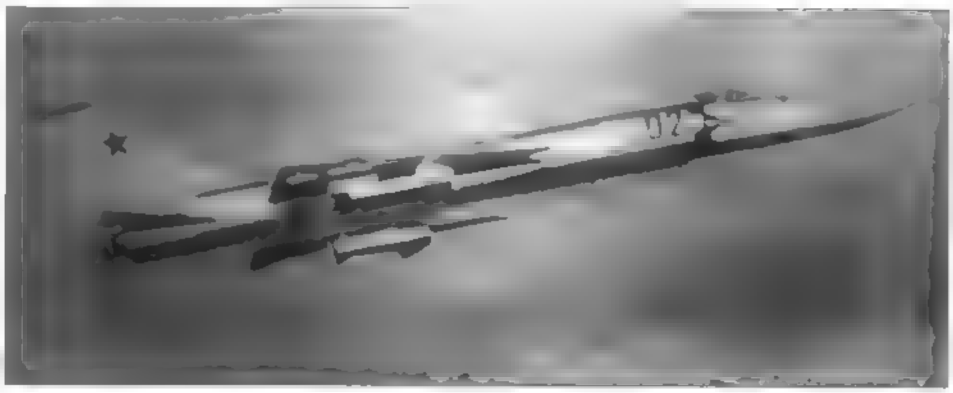
Lavochkin's missiles

In the early 1950s a section of OKB-301 – an aircraft design bureau headed by Semyon Alekseyevich Lavochkin and specialising in fighter design – was reoriented towards developing medium-range air-to-air missiles. These were intended for the '250' (La-250) two-seat heavy interceptor then under development at the same OKB. Until the mid-1960s it was quite common for Soviet aircraft design bureaux to develop such items as ejection seats and missiles in house; only later did specialised design establishments take over this job completely.

Not a single one of these missiles was to see production and service (and neither was the La-250, for that matter); in fact, most of the AAMs described in this chapter did not get off the drawing board at all. When OKB-301 switched from aircraft design to anti-aircraft missile systems in the late 1950s (the La-250 was Lavochkin's last aircraft), all work on air-to-air missiles was terminated.



Above. An artist's impression of the La-250 with *izdeliye* 275 missiles



Below: The first prototype La-250A ('02 Red') with red and white dummy *izdeliye* 275M missiles.

Izdeliye 275 air-to-air missile

The 275' (*izdeliye* 275) beam-riding air-to-air missile was intended for the original '250' (La-250 *sans suffixe*) two-seat heavy interceptor conceived to be powered by two 12,000-kgp (26,455-lbst) Klimov VK-9 afterburning turbojets. The missile formed part of the K-15 aerial intercept weapons system which also included the aircraft itself, a K-15U radar (the suffix letter U probably denoted *oopravleniye* [*snaryadami*] – missile control or guidance) and ground controlled intercept (GCI) equipment. The missiles had a maximum launch range of 15 km (9.3 miles), hence the digits in the system's designation. Two such missiles were to be carried semi-recessed on the fuselage centreline, in a similar way to that which would later be utilised on the Mikoyan MiG-31 heavy interceptor.

The unavailability of the intended VK-9 engines forced Lavochkin to use the Lyul'ka AL-7F afterburning turbojet with a specified thrust of 7,500 kgp (16,535 lbst) dry and 10,000 kgp (22,045 lbst) reheat; hence the aircraft had to be extensively redesigned to fit the much smaller engines. Therefore the *izdeliye* 275 AAM was not tested.

A provisional drawing of the *izdeliye* 275 missile.

The *izdeliye* 275 missile was 6.6 m (21 ft 7⅞ in) long, with a body diameter of 450 mm (1 ft 5¾ in). The wing span was 1.7 m (5 ft 6 ⅞ in) and the rudder span 1.05 m (3 ft 5 21/64 in).

Izdeliye 275A air-to-air missile

The '275A' (*izdeliye* 275A) was a derivative of the '275' AAM developed for the smaller AL-7F powered '250A' (La-250A) interceptor, the missile was scaled down accordingly. Three of the four La-250s used in the flight test programme (except the first one which had the old La-250 *sans suffixe* airframe) were completed to La-250A standard. Here the semi-recessed missile launchers gave way to conventional pylons, one under each wing.

The '275A' missile underwent a series of tests in ballistic mode on a ground launcher, nine launches had been made by the end of

1958 However, the missile never reached the air launch stage; only captive-carry tests of dummy missiles were made on the La-250A prototypes

The missile was powered by a liquid-propellant rocket motor developed by Aleksey M. Isayev and delivering an estimated impulse of 2,830 kgp (6,240 lbst) at 14,000 m (45,930 ft), the burn time was 23 seconds At a launch weight of 600 kg (1,320 lb), including a 140-kg (308-lb) warhead, the missile was to accelerate to a top speed of 3,600 km/h (2,236 mph). Maximum range in controlled flight (that is, maximum 'kill' range) was to be 27 km (16 77 miles). The missile was 5.7 m (18 ft 8¹³⁄₃₂ in) long, with a body diameter of 450 mm (1 ft 5¾ in) and a wing span of 1.55 m (5 ft 1 in)

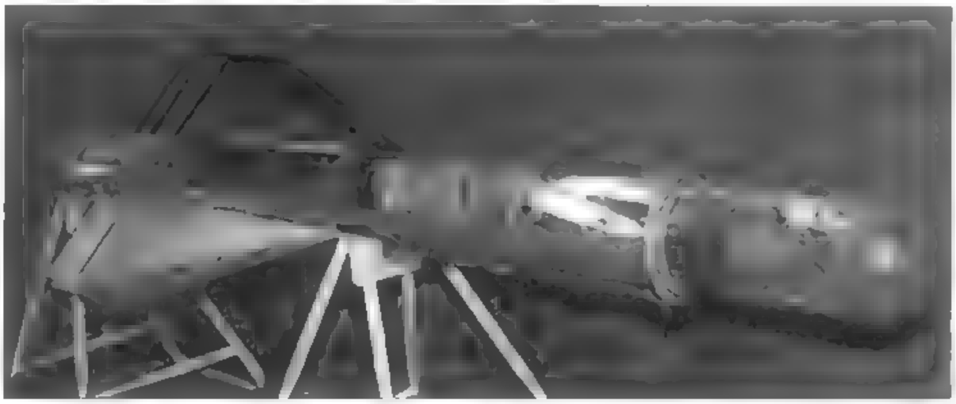
Izdeliye 277 air-to-air missile

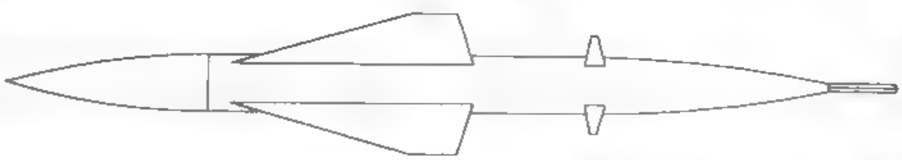
The '277' (*izdeliye* 277) air-to-air missile was likewise intended for the La-250A, it was to supplement the '275A' AAM, differing from it only in having a different seeker head Development was terminated at the project stage due to the cancellation of the La-250 programme

Izdeliye 279 air-to-air missile

The '279' (*izdeliye* 279) was a projected derivative of the '277' AAM featuring a nuclear warhead. It was apparently intended for use against large incoming bomber formations The '279' was likewise abandoned at the project stage.

Toropov's Missiles





In the mid-1950s OKB-134 headed by Chief Designer I. I. Toropov was working on the K-7 and K-75 air-to-air missile systems. Like the RS-1-U missile developed by the competing OKB-2 under Pyotr D. Grooshin (which see), the K-75 was a short-range missile. In contrast, the K-7 (like the K-6 developed by Matus R. Bisnovat's OKB-4) possessed longer range. Eventually neither system was destined to enter service, after which OKB-134's involvement with air-to-air missiles ended

Above left: A cutaway example of the K-7 missile. Note the hemispherical radome and the wings painted to disguise their shape; the canards have probably been removed.

Left: The K-75 AAM. Note the long rear body section terminating in a guidance system aerial

Below: The Yak-25K-75 prototype (c/n 1608) with four K-75s on pylon-mounted launch rails.

K-7 air-to-air missile

The K-7 AAM was developed in two versions featuring different guidance systems – the beam-riding K-7L (the suffix stands for *oopravleniye po luchoo rahdiolokahtora* radar beam guidance) and the homing K-7S (*samonavedeniye* – 'self-guidance'). Actually lower-case suffixes were used, but this rendering would create confusion; thus, 'K-7l' would look like 'K-seven-i' The missile was intended for such varied types as the Yakovlev Yak-25K, Sukhoi T-3 (the forerunner of the Su-9) Mikoyan I-75 and so on

The K-7 was considered to be more advanced and more promising than the competing Bisnovat K-6. However, tests of the missile as part of several aerial intercept weapons systems showed that it did not meet the demands of the Soviet military either. Hence the K-7 programme was discontinued in the late 1950s

K-75 air-to-air missile (*izdeliye* 129)

The K-75 (*izdeliye* 129) beam-riding short-range AAM was designed for the Yak-25K interceptor which formed part of the Yak-25K-75 aerial intercept weapons system. Two such missiles were carried on pylons under each wing inboard of the engine nacelles. Tests of the Yak-25K revealed that the K-75 was inferior to the similarly sized K-5 developed by the Grooshin OKB, which consequently entered production and service as the RS-1-U (see below)

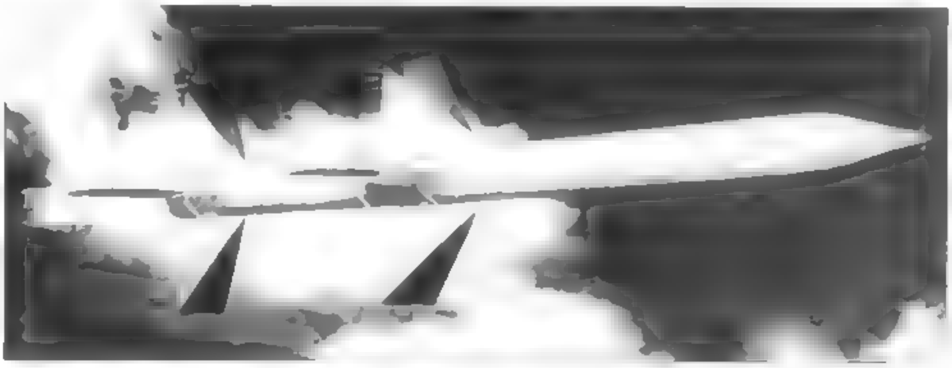
The K-75 was approximately 2.55 m (8 ft 4⅜ in) long, with a body diameter of 200 mm (7⅞ in) and a wing span of 0 6 m (1 ft 11⅝ in)

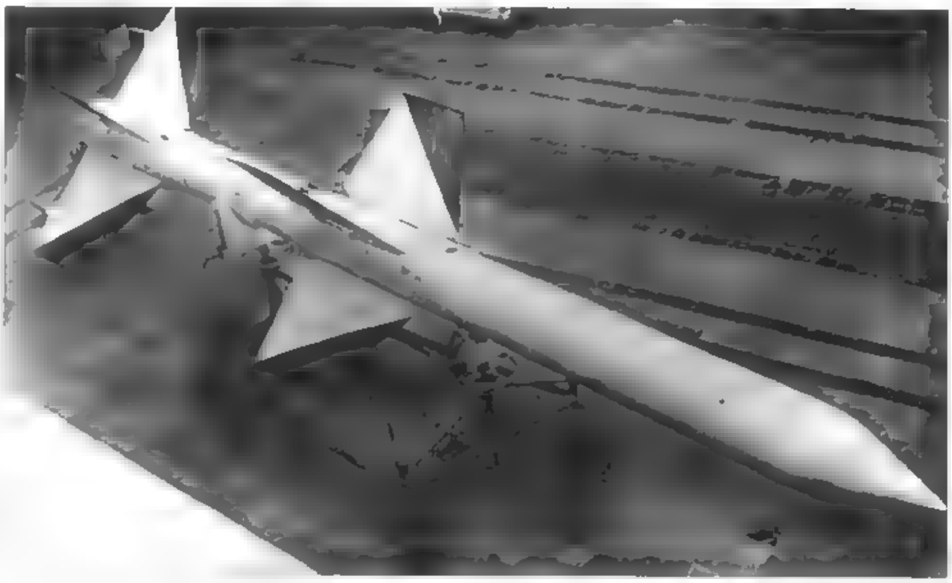
Mikoyan's Missiles

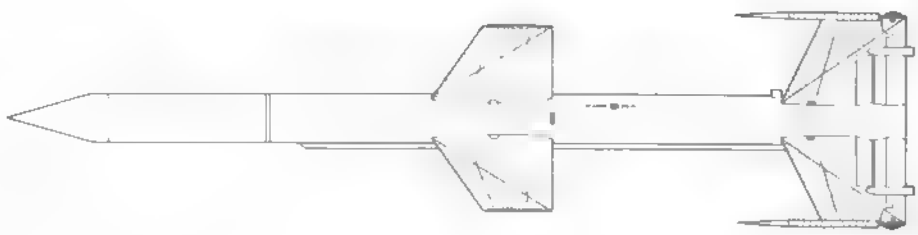
K-9 (K-9-155) air-to-air missile

In 1954 the Soviet Union began development of the Uragan-5 (Hurricane-5, pronounced *ooragahn*), the nation's first integrated automatic aerial intercept weapons system Artyom Ivanovich Mikoyan's OKB-155, one of the two fighter design bureaux working on this system, developed the Ye-150/Ye-152 family of single-engined heavy interceptors The weapons options envisaged for these aircraft for the purpose of selecting the best one included the K-9 semi-active radar homing (SARH) air-to-air missile. (To be precise, the Mikoyan version was designated K-9-155; the K-9-51 developed for the competing Sukhoi T-37 was a quite different missile, despite the similar designation.) The first official mention of this missile was probably in the Council of Ministers directives dated 16th April and 4th June 1958 (the appropriate MAP orders followed on 24th April and 17th June respectively). Mikhail Iosifovich Gurevich, Mikoyan's closest aide and 'co-author' of the MiG brand, was in charge of missile development at the OKB

The conditions in which the K-9 was to be launched (the missile platform's high speed, the high closing rate, the absence of vigorous manoeuvres during the attack and the illumination of the target by a powerful fire control radar) accounted for some peculiarities of the missile's design The powerful



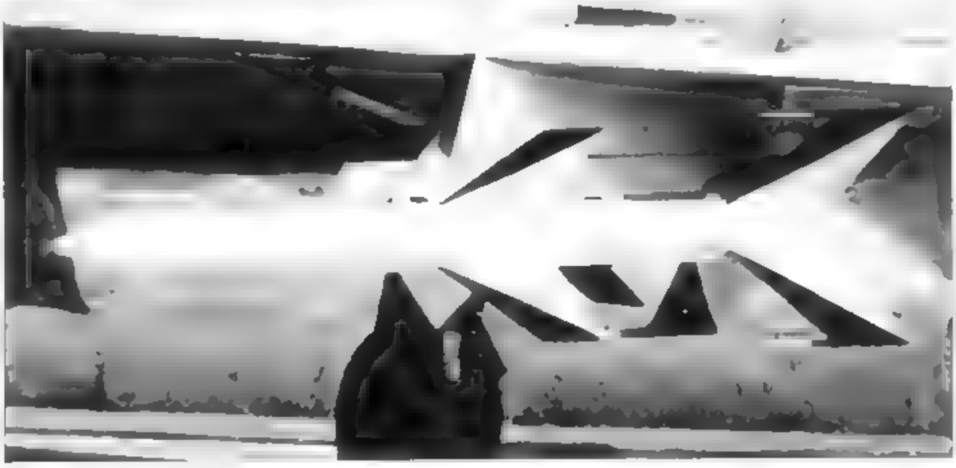




Top right: Artist's impression of the K-9-155 in action

Above right. A dummy K-9-155 in the assembly shop of the Mikoyan OKB's prototype construction facility in Moscow The leading edges of the stabilisers and the large all-movable wings have been painted black to make them look triangular on satellite imagery and fool Western intelligence agencies into thinking this was a Soviet copy of the AIM-7 Sparrow!

Right: A drawing of the K-9-155, showing the ventral conduit, the ailerons and the probe aerials pointing forwards from the tips of all four fins.



Above: The appropriately marked Mikoyan Ye-152A interceptor prototype with two dummy K-9-155s under the wings as shown at the 1961 Aviation Day air display at Moscow-Tushino.

Left: Close-up of a K-9-155 on the launch rail.

Below left: A cutaway drawing of the K-9-155. 1 Semi-active radar seeker head, 2. TsR-1 control module, 3. TsRV-1 radar proximity fuse; 4. Fuse aerials; 5. Safety detonator mechanism; 6. HE, fragmentation warhead; 7. Turbogenerator; 8. Compressed air bottle, 9 All-movable wings; 10 Wing servo, 11. APTs-18 autopilot; 12. PRD-56 two-mode rocket motor; 13 Stabiliser; 14. Rolleron; 15. Aileron, 16. Aileron servo.

two-mode rocket motor delivering an initial impulse of 5,500 kgp (12,125 lbst) accelerated the missile to 1,400 m/sec (5,040 km/h, or 3 130 mph) and then switched to cruise mode with a thrust of 2,500-3,000 kgp (5,510-6,610 lbst). The missile was guided to the target by the beam of the TsP-1 radar

The K-9 had two sets of cruciform supporting/control surfaces. By analogy with aircraft the forward set was called wings (even though they were all-movable) and the rear surfaces were called stabilisers; the latter featured inset ailerons and rollerons. The K-9 had a launch weight of 245 kg (540 lb), including 103 kg (227 lb) for the rocket motor, 15 kg (33 lb) for the seeker head and 27 kg (59 5 lb) for the warhead equipped with a radar proximity fuse. The warhead's lethal radius was 20-30 m (65-100 ft)

The K-9 had all-aspect engagement capability, although the design of the seeker head was far from perfect, limiting effective 'kill' range to 9 km (5.5 miles). The guidance system used

the parallel approach method, which required constant correlation of the radar pulse and the radar echo. Originally the stabilisers carried probe aerials serving the synchronisation channel which received the interceptor's radar pulse; these bulky aerials later gave way to flush antennas on the missile's body

The K-9 proved to be troublesome and the 'kill' probability in a single-missile attack was no more than 55%. Hence the missile was not cleared for production and service Nevertheless, after the 1961 Aviation Day display at Moscow-Tushino the K-9 received the ASCC reporting name AA-4 *Awl*. The missile was about 4.5 m (14 ft 9¼ in) long, with a wingspan of 1.6 m (5 ft 3 in), a stabiliser span of 1.3 m (4 ft 3⅛ in) and a body diameter of 250 mm (1 in)

K-9M air-to-air missile

The K-9M (*modifitseerovannaya* – modified) was a version of the missile described above featuring a slightly modified seeker head which was optimised for working with the Smerch (Tornado) fire control radar instead of the TsP-1. This version fared no better than the basic K-9 (K-9-155)

Grooshin's Missiles (MKB Fakel)

On 26th November 1953 the Soviet Council of Ministers issued a directive establishing the OKB-2 design bureau within the MAP framework, with the well-known aircraft designer Pyotr Dmitriyevich Grooshin as its head. By then Grooshin was no novice in missile design, having worked on a two-stage surface-to-air missile (SAM) for the S-25 *Berkoot* (Golden Eagle) weapons system at the Lavochkin OKB since 1951 (Note The name of the S-25 weapons system was changed to *Dvina* (the name of two rivers in north-eastern Russia) before the system entered service The NATO codename was SA-2 *Guideline*.)

OKB-2 took up residence at plant No 293 – the plant formerly allocated to the defunct OKB of Chief Designer Viktor F Bolkhovitinov which had specialised in fighters The new design bureau was tasked with developing air-to-air missiles and new-generation surface-to-air missiles

Grooshin's design team created the Soviet Union's first air-to-air missiles, the RS-1-U and RS-2-U; these were intended for use against aircraft lacking in speed and agility, such as the American Boeing B-50 Superfortress, Boeing B-52 Stratofortress and Convair B-36 Peacemaker bombers In later years the OKB switched its efforts entirely to developing SAMs and anti-ballistic missiles (ABMs). In 1967 OKB-2 was renamed MKB *Fakel* ('Torch' Machinery Design Bureau; MKB = *mashinostroitel'noye konstrooktorskoye byuro*); it is now headed by General Designer V. G. Svetlov

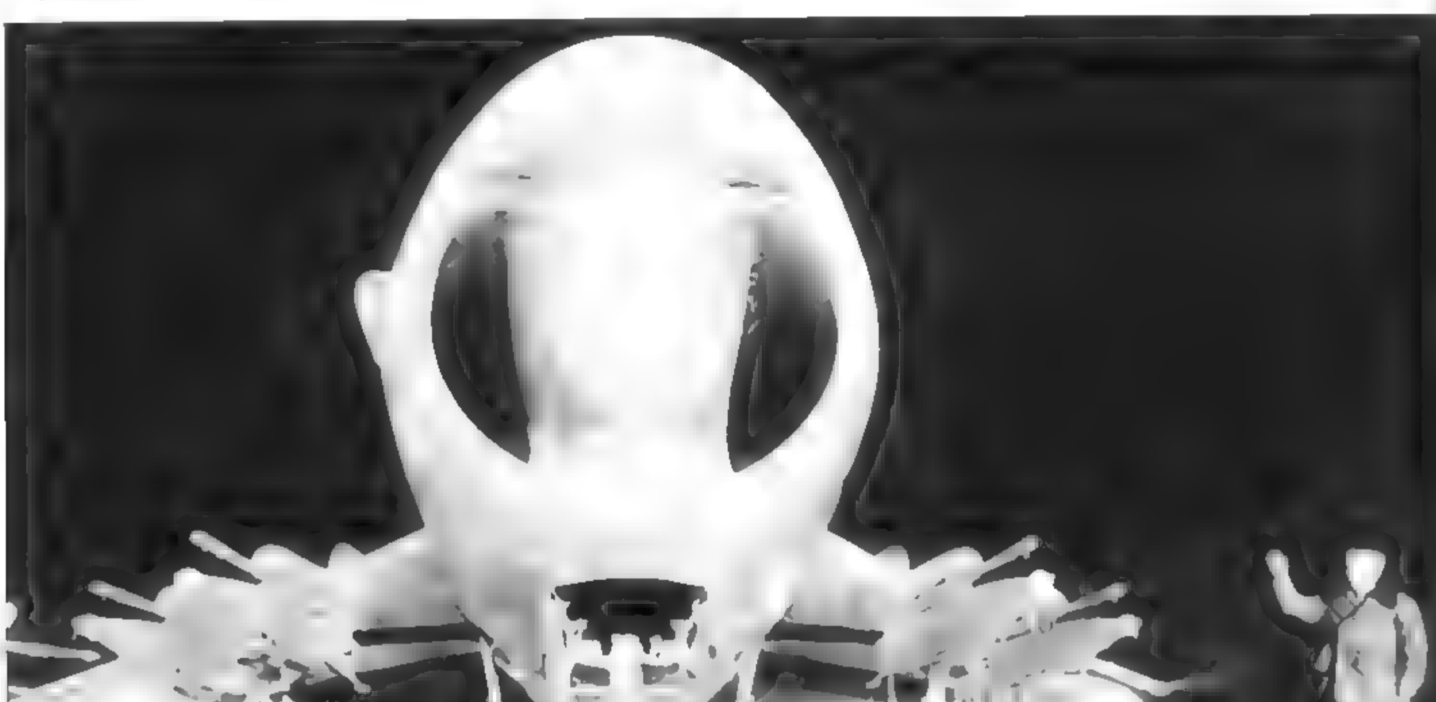
Two RS-1-U missiles under the port wing of a Mikoyan/Gurevich MiG-17PFU all-weather interceptor

RS-1-U (K-5, *izdeliye* 1) air-to-air missile

The RS-1-U missile, also known as *izdeliye* 1, was part of the S-1-U guided missile armament system; the R stood for *raketa* (in this case missile) and the U for *oopravlyayemoye oroozhiye* (guided weapons) Known in Soviet Air Force service as the K-5, the S-1-U system was developed for interceptors, its function was to destroy enemy bombers in pursuit mode, day or night, in any weather conditions. Apart from the missiles, the system included the RP-1 U fire control radar, missile pylons and launch rails and other equipment

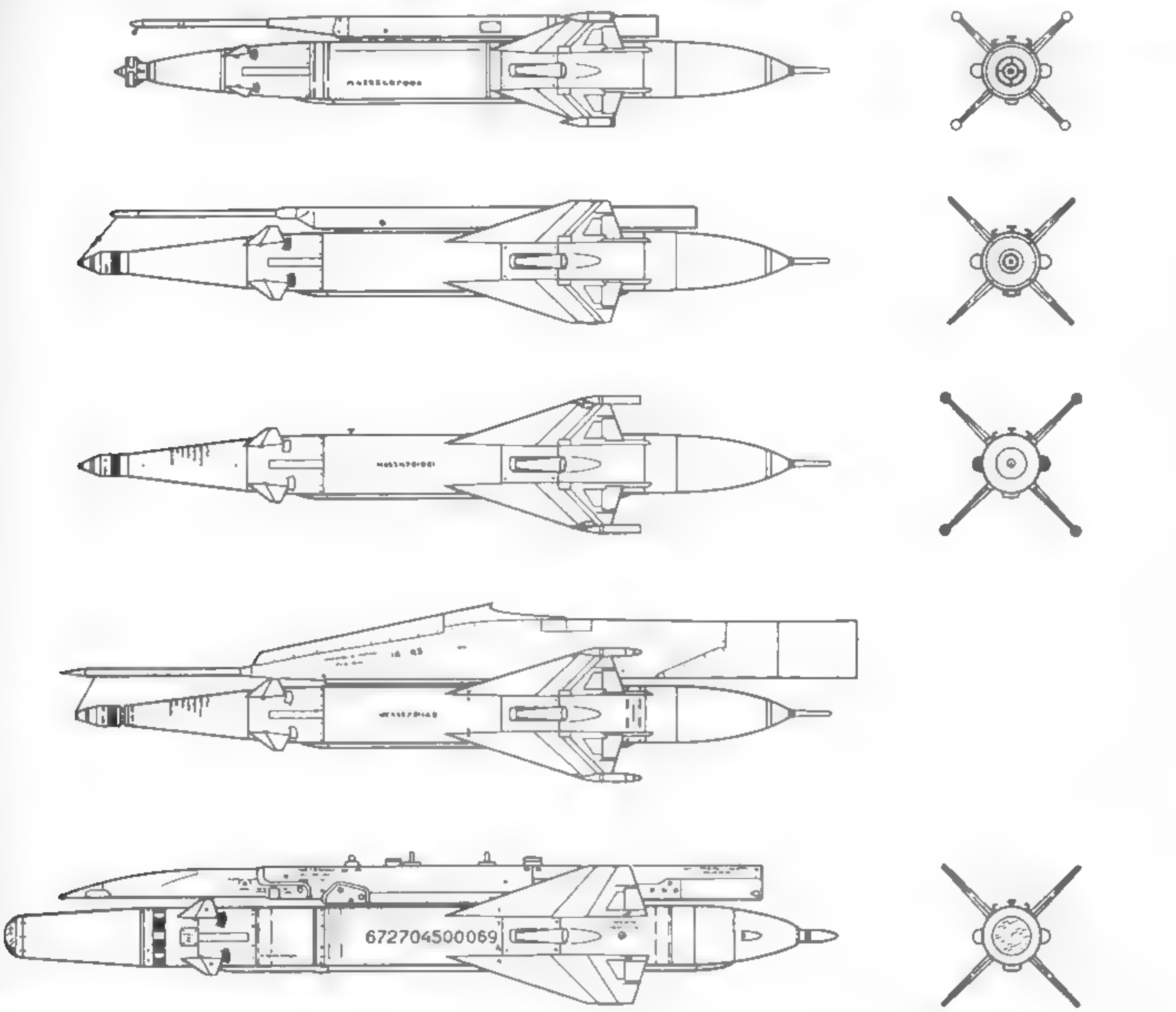
In developing the S-1-U system the Grooshin OKB teamed up with KB-1, a division of the Ministry of Defence Industry (MOP – *Ministerstvo oboronnoy promyshlennosti*), which was responsible for the missile's radio command guidance system, this enterprise is now called NPO *Almaz*

Above and below: Typical Soviet-era publicity shots of guardians of the Motherland's skies – in these cases, MiG-17PFUs with a full complement of RS-1-U missiles and two drop tanks. Note the tracers at the tips of the fins and the characteristic ring-shaped aerials of the proximity fuses, as well as the characteristic shape of the RP-1-U fire control radar's twin radomes.



Right: The forward fuselage of a MiG-17PFU. Note the shape of the missiles' noses and the cables connecting the caps closing the ram air turbine (RAT) intakes on the missiles' noses to the front ends of the APU-3 launch rails

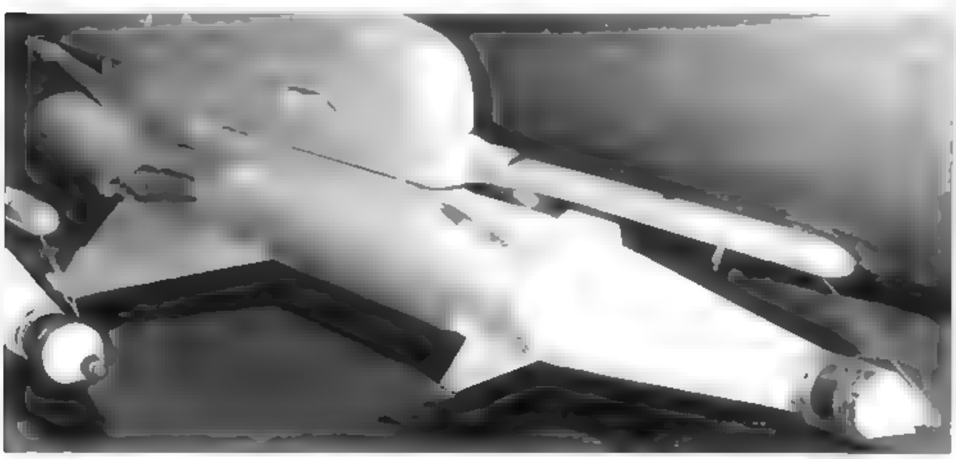
Below: The Toropov OKB's air-to-air missiles. Top to bottom: An RS-1-U missile on an APU-3 launch rail; an RS-2-U with protective cap over the RAT intake and the cap removing cable in place on an APU-4 launch rail, an RS-2-U fitted with tracers at the fin tips, an RS-2-US missile with protective cap on an APU-19 launch rail as fitted to the Su-9. The bottom side view depicts an R-55 missile developed by the Zvezda OKB (see pages 21-22) on an APU-68UM launch rail for the sake of comparison, since this missile was based on the RS-2-U.



('Diamond' Research & Production Association; NPO = *naoochno-proizvodstvennoye obye-dineniye*). Originally KB-1 was headed by Sergey L. Beria – the son of the infamous Lavrentiy P. Beria, Stalin's feared Minister of the Interior. After Stalin's death in May 1953 L. P. Beria was found guilty of high treason and executed, sharing the fate of many he had sent to death. Hence Beria Jr. was removed from office and replaced by K. K. Patrookhin.

The RP-1-U was an adaptation of the RP-1 ***Izumrood-1*** (Emerald-1) centimetre waveband (S-band) twin-antenna gun ranging radar developed by NII-17 in 1948-50 for the MiG-17P interceptor. RP stood for ***rah-diopritsel*** – 'radio sight', in the terminology of the time, while the U stood for *oopravleniye [snaryadami]* – missile control or guidance. The changes as compared to the original model included longer automatic tracking range thanks to the larger diameter of the tracking antenna; a large (bomber-type) target could be detected at 6-10 km (3.7-6.2 miles) range. The radar was linked to an ASP-3NM or ASP-5N automatic gunsight (*avtomaticheskiy strelkovyy pritsel*).

The RS-1-U featured a canard layout with cruciform wings and rudders; all lifting and control surfaces were located at 45° to the horizontal plane. The body with a diameter of 200 mm (7⅞ in) was divided into five sections housing the fragmentation warhead, the radar proximity fuse, the guidance system modules and its power packs, the rudder servos and pneumatic actuators and roll stabilisation system. The foremost section accommodated the 9.2-kg (20.3-lb) warhead and the RV-1-U fuse with a maximum detection radius of 10 m (32 ft 9 in); the skin of the warhead bay served as the fragmentation liner. The fuse, which was housed in a characteristically bulged fairing at the forward extremity of the missile's body, was screwed into a threaded hole. It used the Doppler principle and was powered by a very compact generator with a ram air turbine (RAT) located inside the fairing; until the moment of launch the RAT air intake was



Above: An interesting mix of subsonic MiG-17PFUs and supersonic MiG-19PMs (nearest to camera) on the flight line of an Air Defence Force fighter unit in the southern regions of the Soviet Union (as indicated by the 'tropical-style' uniform of the armourers pulling the dolly in the foreground. The dolly is loaded with RS-1-Us and RS-2-USs for both types, facing alternatively left and right and fitted with protective covers over the noses.

Left: RS-2-US missiles on the pylons of a MiG-19PM. Note the longer conical nose and the RV-2-U proximity fuse with protective cap.

Right: An RS-2-U and an R-3 in a Vietnamese [redacted]

Below right: Another RS-2-U in a different Vietnamese museum. Curiously, the missile is marked BB-13M' – probably a Vietnamese designation of the RS-2-U.

closed by a safety cap which was whipped off by a cable attached to the pylon as the missile departed The annular emitter/receiver aerial of the fuse was mounted externally on the said fairing. The fuse's electronic circuitry utilised vacuum tubes

Section 2 housed the rudder control actuators and the rudders proper. The latter had a symmetrical rhomboid airfoil with sharp leading and trailing edges and were one-piece stamped parts made of aluminium alloy

Section 3 contained the solid-fuel rocket motor delivering an initial impulse of 3,000 kgp (6,610 lbst) at sea level. The combustion chamber formed part of the body; it had a bifurcated outlet with lateral nozzles angled outward 15°. An electrical equipment bay housing a power pack was located at the rear of the section (aft of the combustion chamber). A conduit enclosing compressed air piping and wiring ran along the underside of Section 3.

Section 4 was the control system bay accommodating sensors, gyros, the aileron servos and actuators, as well as a compressed air bottle for the latter. More control system components, namely the electronic modules converting the pulses of the interceptor's RP-1-U radar into electric signals fed to the control servos, were housed in Section 5 which was the tailcone, the latter carried an aft-pointing rod aerial receiving the radar signals

The trapezoidal wings were aluminium alloy castings attached to Section 4 of the missile's body. They had a leading-edge sweep of 65° and a flattened hexagonal airfoil Inset ailerons were located at the root sections of the trailing edges; the wingtips carried tracers in bullet-shaped fairings allowing the pilot to track the missile's trajectory at night. Some RS-1-Us, however, were manufactured without the tracers

The ailerons served for roll control, helping to stabilise the missile along the longitudinal axis; they were controlled by a self-contained control system module in the rear body section Pitch and directional control was exercised by the canard foreplanes (rudders) in response to the commands transmitted via the guidance channel. To maximise control efficiency (among other things, to ensure the same response at varying speeds and altitudes) the missile's control surface deflection increased together with the flight level

The RS-1-U missiles were carried on APU-3 launch rails (*aviatsionnoye pooskovoye oostroystvo* – aircraft-mounted launcher) attached to wing-mounted pylons; the launch was controlled by a fire selector device. The APU-3 was similar in design to the PU-21 launch rail developed for the ARS-21 heavy unguided rocket

The RS-1-U was a beam-riding missile After achieving radar lock-on the interceptor pilot would aim his weapons by superimposing the 'blip' on the radar display on the reticle of the ASP-3NM or ASP-5N sight During the first second after launch the missile flew in autostabilisation mode, stabilised around all three axes, then it caught the beam of the RP-1-U radar and became controllable, the radar signal being converted into control inputs by the missile's guidance system. The system kept the missile on the radar beam's axis, taking corrective action to return the missile to this axis if it deviated If no hit had been scored, the missile would self-destruct in 13 to 23 seconds At the point of burnout the RS-1-U accelerated to 800 m/sec (2,880 km/h, or 1,788 mph), the maximum effective 'kill' range was 3 km (1.86 miles)

The S-1-U armament system found use on three production interceptors evolved in the mid-1950s from cannon-armed jet fighters – the Mikoyan/Gurevich MiG-17PFU, MiG-19PM and Yakovlev Yak-25K based on the MiG-17PF, MiG-19P and Yak-25M respectively All of these aircraft carried four RS-1-U (K-5) missiles on underwing pylons

RS-2-U (K-5M, *izdeliye* I) air-to-air missile

Known in-house as *izdeliye* I, the RS-2-U AAM was a refined version of the RS-1-U offering higher performance and increased lethality. It was part of the S-2-U guided missile armament system developed specifically for the MiG-19PM with a view to replacing the existing S-1-U system; the sys-

Left: Two RS-2-US missiles under the port wing of a Su-9 interceptor The missile on the outboard pylon is painted a dark colour (probably red) and must be an instrumented test round Note the aft-pointing probe aerials of the guidance system on the missiles' tailcones.

tem also included the RP-2-U fire control radar and four APU-4 missile rails As in the case of the earlier S-1-U, the missiles could be fired singly, in pairs or in a salvo with preset intervals

Structurally the RS-2-U was almost identical to the predecessor but featured a new radar proximity fuse designated RV-2-U, this utilised the same Doppler principle but had a larger detection radius (15 m/49 ft) and looked different. The overall length increased by just 14 cm (5½ in) but the missile was 8 kg (17 6 lb) heavier, the warhead weight increasing by 3 5 kg (7.7 lb). This was achieved by extending the warhead section and shortening the rudder actuator bay, the rudders themselves were moved aft Additionally, the RS-2-U differed from the RS-1-U in having wings and rudders with longer span and greater area; the wings were manufactured of magnesium alloy to save weight. Again, the RS-2-U came in two versions – with or without tracers at the wingtips

The improved RP-2-U radar, together with the changes in the missile's design, afforded a minor increase in effective 'kill' range More significant was the improvement in launch altitudes as far as both maximum and minimum altitude were concerned

In addition to the production MiG-19PM, the S-2-U armament system was used on the SM-12PM experimental derivative of the MiG-19 and other development aircraft

RS-2-US (K-5MS, *Izdeliye* IS) air-to-air missile

The S-1-U and S-2-U systems had been developed for subsonic interceptors or aircraft capable of speeds only just over Mach 1. However, the advent of interceptors designed for much higher speeds and altitudes in the late 1950s created the need to adapt the production RS-2-U missile to the new conditions

The reason was that the existing hardware of the Soviet Air Defence Force (PVO) was no match for the US Air Force's high-flying reconnaissance aircraft which frequently intruded into Soviet airspace True, by then the Sukhoi, Mikoyan and Yakovlev design bureaux had created the T-3, I-7K and Yak-27K supersonic interceptors respectively. However, all of them were to be armed with the new K-6 AAM created by the Bisnovat OKB (see below), and development of this weapon was dragging on and on, with no end in sight.

The following table gives the specifications of the missile family originating in the RS-1-U.

	RS-1-U	RS-2-U	RS-2-US	R-55
Product code	*Izdeliye* 1	*Izdeliye* I	*Izdeliye* IS	*Izdeliye* 67
Codename				
US	AA-1	AA-1A	AA-1A	AA-1B
NATO (ASCC)	*Alkali*	*Alkali*	*Alkali*	*Alkali*
Service entry	1957	1958	1960	1972
Calibre	200 mm (7⅞ in)	200 mm (7⅞ in)	200 mm (7⅞ in)	200 mm (7⅞ in)
Length overall	2.356 m (7 ft 8¾ in)	2 494 m (8 ft 2³⁄₁₆ in)	2 50 m (8 ft 2³⁄₁₆ in)	2 76 m (9 ft 0⅝ in)
Wing span	0 549 m (1 ft 9⁹⁄₁₆ in)	0 650 m (2 ft 1⁹⁄₁₆ in)	0 654 m (2 ft 1¾ in)	0 650 m (2 ft 1⁹⁄₁₆ in)
Launch weight kg (lb)	74.2 (163 5)	82.2 (181 2)	82 7 (182 3)	91 1 (200.8)
Warhead weight, kg (lb)	9.2 (20 28)	13.0 (28.66)	13.0 (28.66)	8.6 (18.96)
'Kill' range, km (miles)	2-3 (1.24-1.86)	2.5-3.5 (1.55-2.17)	2.5-3.5 (1.55-2.17)	1.2-2.8 (0.75-1.74)
Launch altitude, m (ft)	5,000-10,000 (16,400-32,810)	2,500-16,500 (8 200-54 130)	2,500-16,500/20,500* (8,200-54 130/67 260*)	0-22,000 (0-72 180)
Speed, m/sec (km/h; mph)	800 (2 880, 1,788)	800 (2 880, 1,788)	800 (2 880, 1,788)	800 (2,880; 1 788,
Launch rail type	APU-3	APU-4	APU-4, APU-19, APU-20	APU-68UM
Missile platform	MiG-17PFU MiG-19PM Yak-25K	MiG-19PM SM-12PM	MiG-19PM SM-12PMU Su-9 MiG-21PFM/R/MF	MiG-21*bis*

* When carried by the MiG-19PM/Su-9 respectively

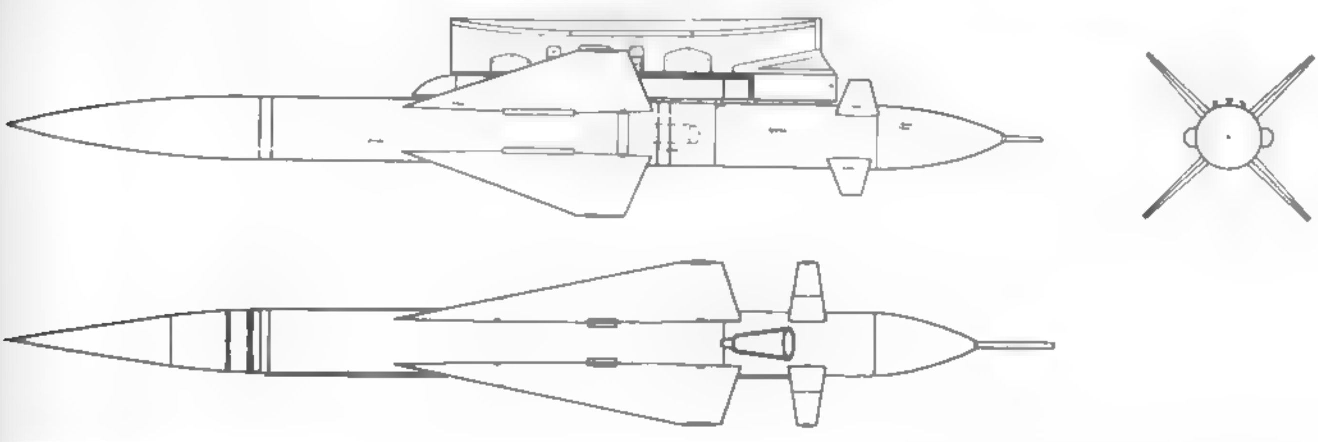
In order to make the RS-2-U missile used by the MiG-19PM (as part of the S-2-U system) suitable for the Sukhoi T-3, which became the Su-9 in production form, certain changes were introduced into the design. The result was the RS 2-US (*izdeliye* IS) forming part of the S-2-US armament system, the S suffix was a reference to Sukhoi. The missile differed from the preceding version in having a revised fuse and new tracers which could burn at higher altitude where the air was thinner. The RV-2-US fuse had a 6 mm (15/64 in) longer body made of a new material with better heat-resistant properties and had a shorter time delay.

Since the RS-2-US was suitable both for the MiG-19PM and for the Su-9, which had rather different performance, a two-position switch marked 'S' (equals Su-9) and 'I' (equals MiG-19PM) was installed under a cover on the missile's body for selecting the aircraft type prior to take-off. Depending on its position, the rudder deflection limits at different altitudes varied. The launch altitude range also differed, being 2,500-16,500 m (8,200-54,130 ft) for the 'I' setting and 2,500-20,500 m (8,200-67,260 ft) for the 'S' setting.

On the Su-9 the missiles were carried on two different types of launch rails - APU-19s on the inboard pylons and APU-20s on the outboard ones. On early-production aircraft

Right: A Su-9 pilot poses beside his aircraft which appears to be fully armed with four RS-2-US missiles. Note that the tips of the APU-19 and APU-20 launch rails are pointed because of the Su-9's high speed, so the ground personnel has to be extra careful to avoid injury.

Below: Two very different versions of the K-6. The upper drawing depicts the dummy version of the K-6 *sans suffixe* carried by the SM-6 on pages 22-23, the intended position of the rocket motor nozzles being shown by hatched lines. The other version is the K-6V optimised for high altitudes, note the larger wings with increased sweepback, the longer rudders located further forward and the different position of the nozzles.



the weapons were guided to the target by a TsD-30T fire control radar which was replaced by a more modern RP-9U radar on later examples

Apart from the types mentioned above the RS-2-US was used on the Mikoyan SM-12PM, SM-12PMU and MiG-19PMU high-altitude interceptors equipped with a liquid-fuel rocket booster in a ventral pack Also, in the 1960s this missile found use on the MiG-21PFM, MiG-21R and MiG-21MF tactical fighters featuring the RP-21M fire control radar, in these cases the RS-2-US was carried on APU-7 launch rails

K-6 air-to-air missile

One of the Grooshin OKB's first air-to-air missiles in general and its only medium-range AAM in particular was the K-6 missile sharing the 'mid-engine' layout of the earlier RS-1-U and RS-2-U Several versions were envisaged, including the K-6V optimised for high altitudes (V = *vysotnaya*) and a version featuring movable wings for better agility. They differed considerably in the shape and relative position of the wings, rudders and rocket motor nozzles

Like the K-7 developed by the Toropov OKB, the K-6 was intended for the Sukhoi T-3, Mikoyan/Gurevich I-7K and Yakovlev Yak-27K interceptors The Mikoyan OKB modified a number of MiG-19 fighters for testing the new missile (these weapons testbeds were known as the SM-2I, SM-6 and SM 24)

Because the stringent requirements posed by the military proved difficult to meet, the development of the K-6 missile dragged on far longer than planned which eventually led to the cancellation of the programme in the late 1950s

Top and upper left Though the K-6 missile was not accepted for production and service, this cutaway K-6V survives in the museum of MKB Fakel These views show well the missile's unusual exterior with high aspect ratio unswept rudders aft of the cropped-delta wings, the lateral nozzles and the very long nose and tail sections (the latter with a guidance system probe aerial) Note also the pure conical shape of the nose section.

Lower left: The K-6 missile was put through its paces on several weapons testbed versions of the MiG-19, including the SM-6 based on the MiG-19 *sans suffixe* One of the two SM-6s built by the Gor'kiy aircraft factory (c/n 210101 or 210102) is shown here.

Left: Another view of the SM-6 with a dummy K-6 and a cine camera 'egg' under the wing root; the camera points forward for recording actual missile launches in the event the powered version is fitted Note that this version of the missile has much smaller rudders located further aft The low-set horizontal tail characteristic of the *Farmer-A* the is also clearly visible

Right: Close-up of a dummy K-6 *sans suffixe* (note the absence of the rocket motor nozzles and rear guidance system aerial) on the starboard pylon of an SM-6 for captive-carry tests. Note the cine camera pods suspended from two small pylons further inboard. The camera in the outer pod faces outboard and aft to capture the actual moment of separation

The K-6 missile was approximately 3.8 m (12 ft 5⅝ in) long, with a body diameter of 235 mm (9¼ in). The wing span was 0.86 m (2 ft 9⅞ in) and the rudder span was 0.6 m (1 ft 11⅝ in)

The Missiles of the Zvezda OKB

The *Zvezda* (Star) OKB was established in 1966 as the successor of the design office of the factory which had produced such aircraft weapons as the RS-1-U, RS-2-US, R-8M, R-4 and so on at various times. Apart from supporting the production of these AAMs, the staff of the design office developed unusual target drones intended for training fighter pilots in using air-to-air missiles; these drones were effectively missiles lacking warheads. Putting this experience to good use, in the mid-1960s the design team headed by N. T. Pikot developed the R-55 air-to-air missile as a 'private venture', after comprehensive testing on the Su-9, Su-15, MiG-21*bis* and other interceptor types the missile was cleared for production. The experience gained with the R-55 proved valuable when the same team started work on the Soviet Union's first tactical air-to-surface missile.

In 1966 the Soviet government issued a directive granting Pikot's design team OKB status. The Zvezda OKB became the nation's leading specialist enterprise developing air-to-surface missiles which are described in a separate chapter

R-55 (*izdeliye* 67) air-to-air missile

Designed to replace the RS-2-US, the R-55 (*izdeliye* 67) short-range AAM was based on the former missile's components and had identical applications. The missile shared the RS-2-US's canard layout and the propulsion section was borrowed in as was condition. The forward section was new, incorporating a new S-59 infra-red seeker head; the latter featured a cooling system and high ECM resistance, allowing the missile to be used at altitudes between sea level and 22,000 m (72,180 ft). Maximum 'kill' range was 1.2-2.8 km (0.75-1.74 miles), depending on the target's size and heat signature.

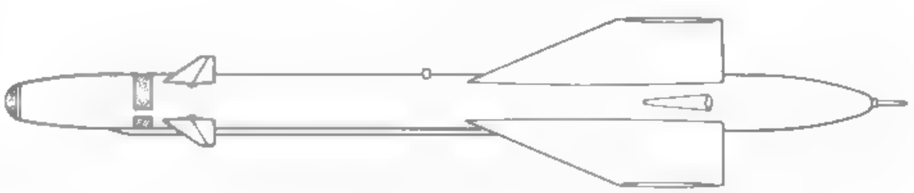
Section 2 of the missile's body housed the electropneumatic rudder actuators, the NOV-55 optical proximity fuse (*nekontaktnyy opticheskiy vzryvahtel'*) and the warhead's forward module; it carried the rudders and incorporated 'viewing ports' for the fuse. The NOV-55 was a passive fuse featuring two independent optical channels working at different angles to the missile's axis; it was triggered by the heat emitted by the target within a certain radius.

The fragmentation warhead consisted of two modules spaced fore and aft. They were detonated simultaneously by a special mechanism located in a ventral fairing. Despite the 25% lower warhead weight as compared to the RS-2-US, the new missile was much more lethal because the fragments spread out in all directions.

Section 4 was similar to that of the RS-2-US but somewhat longer. It accommodated the rear module of the warhead and the safety detonator mechanism which initiated self-destruction 32-38 seconds after launch if no hit had been scored. The wings were again similar to those of the RS-2-US, featuring the same span but having greater area; as compared to the progenitor the R-55 was 26 cm (10¼ in) longer and 8.4 kg (18.5 lb) heavier.

The R-55 was part of an armament system which also included the MiG-21*bis* fighter's RP-21SM radar and APU-68UM launch rails carried on the inboard wing hardpoints. Once the radar had achieved a lock-on, the missile's seeker head was oriented towards the target via an interface module. After launch the missile homed in on the target independently, using the target's heat signature

Right: This drawing depicts the projected K-55M missile developed by the Zvezda OKB. The missile was very different from the 'straight' R-55 shown on page 17. Note the windows of the optical proximity fuse ahead of the rudders.



Bisnovat's Missiles (GMKB Vympel)

Matus Ruvimovich Bisnovat's involvement in aircraft design dated back to the early 1930s. As early as 1934 he had risen to the important post of Deputy Chief Designer in the design section of the Experimental Aircraft Construction Department (KOSOS – *Konstrooktorskiy otdel sektora opytnovo samolyotostroyeniya*) at the Central Aero- & Hydrodynamics Institute named after Nikolay Ye. Zhukovskiy (TsAGI – *Tsentrahl'nyy aero- i ghidrodinamicheskiy institoot*). The SK-1 and SK-2 experimental high-speed aircraft were created there under his direction. In 1948 the Council of Ministers issued a directive reassigning the plant previously

managed by 'fighter maker' Viktor F Bolkhovitinov, whose OKB had been closed down, to the newly-established OKB-293 headed by Bisnovat. The OKB was to develop 'unmanned homing aerial vehicles in the surface-to-surface and air-to-surface classes' (that is, missiles) At that time Matus R Bisnovat supervised the development of several rocket-propelled manned experimental aircraft, including the B-5.

In 1954 the Bisnovat OKB was renumbered, becoming OKB-4. Its main specialisation was now air-to-air missiles of all classes (short-, medium- and long-range) Today the company, which changed its name again in 1967 to become GMKB ***Vympel*** ('Pennant' State Machinery Design Bureau; GMKB = *gosoodarstvennoye mashinostroitel'noye konstrooktorskoye byuro*), is led by General Designer Ghennadiy Sokolovskiy and is now Russia's No.1 enterprise in this field

The short-range AAMs

These missiles were developed for the Soviet Air Defence Force's early jet interceptors (the MiG-17PFU, MiG-19PM, Su-9 and others) and for the Soviet Air Force's tactical fighters whose principal method of utilisation was dogfighting. In later years they found use on PVO interceptors as a 'last-resort' close-in weapon.

R-3S (K-13, *izdeliye* 310A) air-to-air missile

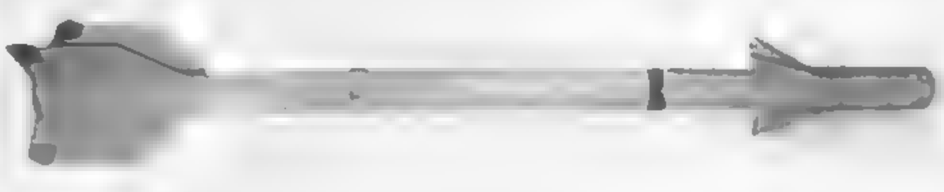
The R-3S infra-red homing missile was designed for attacks in pursuit mode, day and night, in clear weather only. It was a 'fire and forget' weapon – the aircraft could alter its flight profile after firing the missile

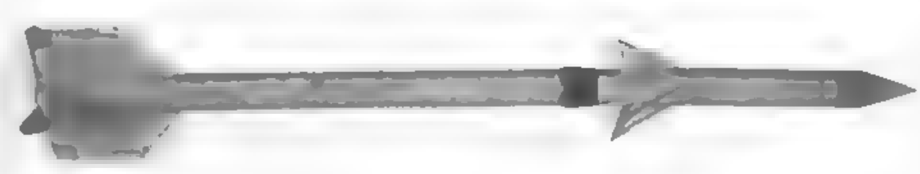
In the late 1950s, when the R-3S was being created, guided air-to-air weapons were a privilege of the PVO's interceptors, and even these were fairly primitive missiles with no homing capability. The fighters of the Air Force (VVS) still had to make do with cannons When the first indigenous homing AAMs became available in prototype form, they were again intended for interceptors and unsuitable for tactical fighters due to low operational G limits precluding their use in a dogfight, they were also bulky and heavy Meanwhile, the air forces of the Western world already had such missiles on strength

In 1958 the Soviet Union obtained an example of the Naval Weapons Center (NWC) AIM-9 Sidewinder IR-homing AAM via China, the missile had been recovered from the wreckage of a US Navy fighter that had intruded into Chinese airspace and had been shot down (such incursions were frequent in those days). Bisnovat's OKB-4 was tasked with copying the American missile in parallel with the development of the indigenous R 8 AAM It should be noted that reverse-engineering (that is, copying) somebody else's missile is by no means as easy as one might suppose It involves carefully studying the design (with no original design documents to fall back on), making renewed calculations for all parts and components and selecting appropriate indigenous structural materials – or creating them from scratch if no suitable materials are at hand

The work progressed at a speedy pace, and as early as 1959 the first Soviet copies of the Sidewinder (known as the R-3) were undergoing flight tests on the Mikoyan SM-9/3T development aircraft (a modified MiG-19S day fighter) This was followed by a new series of tests on the Mikoyan Ye-6T fighter prototype, a precursor of the MiG-21F. Upon completion of the test programme the suitably modified missile was cleared for production and service as the R-3S (alias K-13 or *izdeliye* 310A); the S stood for ***sereeynaya*** (production, used attributively) The first aircraft to carry the new missile as a standard option was the MiG-21F-13 (the second production version), the '-13' suffix referring to the K-13 designation, this aircraft retained one of the original MiG-21F's two cannons Soon afterwards the opinion that tactical fighters do not need built-in cannons – a misconception, as it turned out – became prevalent among the Soviet military top brass. It was quite a while before the internal cannon made a comeback, this was largely thanks to Vietnam War experience – Vietnamese MiG-21PF-Vs found themselves defenceless when the two K-13 missiles had been expended.

The R-3S utilises the canard layout with cruciform delta rudders and cruciform trapezoidal fins. The missile's body consists of four sections Section 1 is divided into two bays accommodating the IR seeker head and the rudder actuators respectively. The all-movable rudders of delta planform with swept trailing edges are located in the same planes as the fins; the rudder actuators are powered by powder gases bled from the rocket motor. The rudders serve a dual purpose, their main function is pitch and yaw control, but the leading edges incorporate four impact fuses detonating the warhead if the missile scores a direct hit

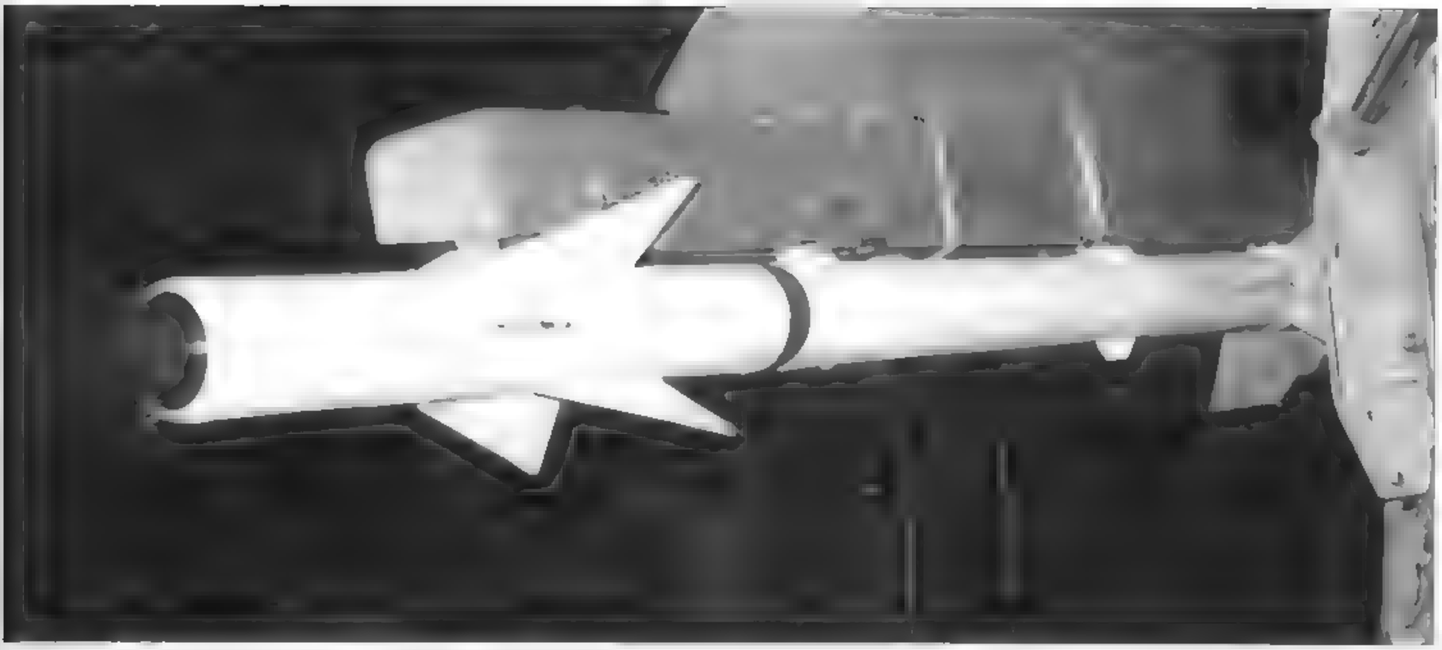




Top left: The IR-homing R-3S was a reverse-engineered version of the NWC AIM-9 Sidewinder. The dark band aft of the rudders is the lens of the optical proximity fuse.

Above left: The R-3R featured a longer forward section housing a radar seeker head in a conical radome and a Yastreb radar proximity fuse.

Left The K-13M was the ultimate version of the 'Soviet Sidewinder', featuring a different internal layout, hence the position of the rudders immediately aft of the IR seeker head.



Section 2 houses the fragmentation warhead. The skin of the section serves as the fragmentation liner and is designed in such a way as to provide a directional fragment scatter pattern Section 3 accommodates the optical proximity fuse with a 9-m (29 ft) detection limit reacting to the target's heat signature, a transparent 'viewing ring' is provided in the skin of this section If the missile misses the target by more than 9 m it self-destructs 25 or 26 seconds after launch, controlled flight time is 21 seconds

Section 4 is occupied by a solid-fuel rocket motor with a single aft positioned axisymmetrical nozzle delivering an initial impulse of 3 800 kgp (8 380 lbst) The body of Section 4 mounts four fins set at 45° to the horizontal plane, these are of trapezoidal planform, with unswept trailing edges. Three mounting lugs are provided on the upper side of the missile's body

For stabilising the missile in the roll channel the fins incorporate rollerons instead of conventional ailerons Rollerons are small metal wheels set into the tips of the fins at the trailing edge so that they only just protrude beyond the span The rims of the wheels are saw-toothed, these indentations are oriented against the direction of flight acting as air scoops so that the slipstream spins the wheels up to about 70,000 rpm When the missile banks, the furiously spinning rollerons create a gyroscopic force acting on the fins which neutralises the bank

The MiG 21F 13, MiG 21PF and subsequent versions of the *Fishbed* carried two or four R-3S missiles on underwing APU-13 launch rails (or APU-13U-1 etc, depending on the version of the aircraft). The R 3S was also carried initially by the MiG 23 'swing-wing' tactical fighter and even the Su-20 fighter-bomber which found use as an interceptor in the Egyptian Air Force during the 1970s The MiG 23 carried the R-3S on APU-13MT launch rails under the fixed wing gloves and the fuselage. However, missile launches from the fuselage pylons were sometimes accompanied by engine flame-outs, which led the Mikoyan OKB to prohibit using these pylons for carrying the R-3S and its derivatives, the ban on carrying AAMs on the fuselage hardpoints was eventually lifted when the R 60 missile became available

R-3U (*izdeliye* 318) acquisition round

The R-3U (*oochebnaya* – training, used attributively), alias *izdeliye* 318, is the fixed acquisition round version of the R 3S designed for training pilots in using the real thing. When staging a mock attack using the R-3U, the pilot performs all the operations prescribed for the live R 3S, the round emits the 'lock-on achieved' buzzer sound and emulates a launch while staying on the pylon all the way Meanwhile, built-in recording equipment captures the pilot's actions for debriefing purposes, showing whether all pre-launch operations have been performed correctly and all requirements have been observed

Structurally the R-3U is a standard R-3S fuselage minus fins, rudders and powerplant Overall length is unchanged, whereas the weight is reduced to 52 6 kg (116 lb)

The forward bay of Section 1 still houses an IR seeker head – the same as on the

Above: An early-model R-3S heat-seeking missile on a BD3-60-21U launch rail under the starboard wing of a MiG-21 fighter Note the raked-delta shape of the rudders and the cylindrical body of the seeker head

Right: Another view of an R-3S suspended beneath a MiG-21PFM, with an RS-2-US, an S-24 heavy unguided rocket and various bombs arrayed alongside for a display

Left: This photo gives an interesting comparison of the R-3R (left) and the 'second-generation' R-13M. The body diameter is identical but the R-13M has larger fins and rudders; the latter feature stronger sweep on both leading and trailing edges.

R-3S; now, however, the signals it generates are fed to a data recorder instead of the rudder actuator servos. The actuators themselves in the rear bay have given way to an electric clock which triggers the data recorder's time marker mechanism at preset intervals. The explosive charge in Section 2 is replaced with the data recorder which records time interval markers, 'Lock-on' and 'Launch' signals and so on. Sections 3 and 4 are empty, except for ballast at the rear of Section 4 provided for CG reasons

Apart from the absence of fins and rudders, the R-3U can be identified by its 'barber pole' colour scheme with four red bands 50 mm (1$\frac{31}{32}$ in) wide

Deliveries of the acquisition round began in 1963. Besides *izdeliye* 318, two other training versions of the missile were available; these were the *izdeliye* 301A (an aerodynamic mock-up of the R-3S – with fins and rudders, that is, hence the A for ***aerodinamicheskiy maket***) and *izdeliye* 301AG (ditto with a functional seeker head, hence the G for ***golovka samonavedeniya***). These were designed for the same training missions but lacked the data recorder

R-3R (K-13R, *izdeliye* 320) air-to-air missile

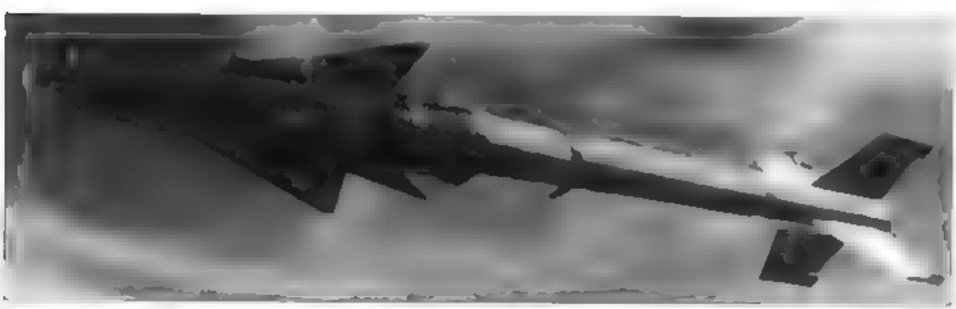
Despite the similar designation, the R-3R (*izdeliye* 320) derived from the R-3S in 1965 was, in effect, a next-generation missile. Its commonality with the predecessor was limited to the warhead, the rocket motor and the fins The increase in efficiency was due to a new semi-active radar seeker head, a new rudder actuator package and a ***Yastreb*** (Hawk) radar proximity fuse. The changes increased the missile's length by 580 mm (1 ft 10$\frac{53}{64}$ in) and the weight by 7 1 kg (15 6 lb) Unlike the R-3S, which can only be used in pursuit mode, the R-3R has all-aspect engagement capability

The SARH seeker head is enclosed by a dielectric fairing. The bay further aft accommodates the power pack and the rudder actuators. The rudders are identical to those of the R-3S, but the actuator package has been augmented by an electronic module adjusting rudder deflection to suit the flight mode. The rudder deflection angles change in accordance with the altitude (there are three preset altitude ranges) and the distance to the target

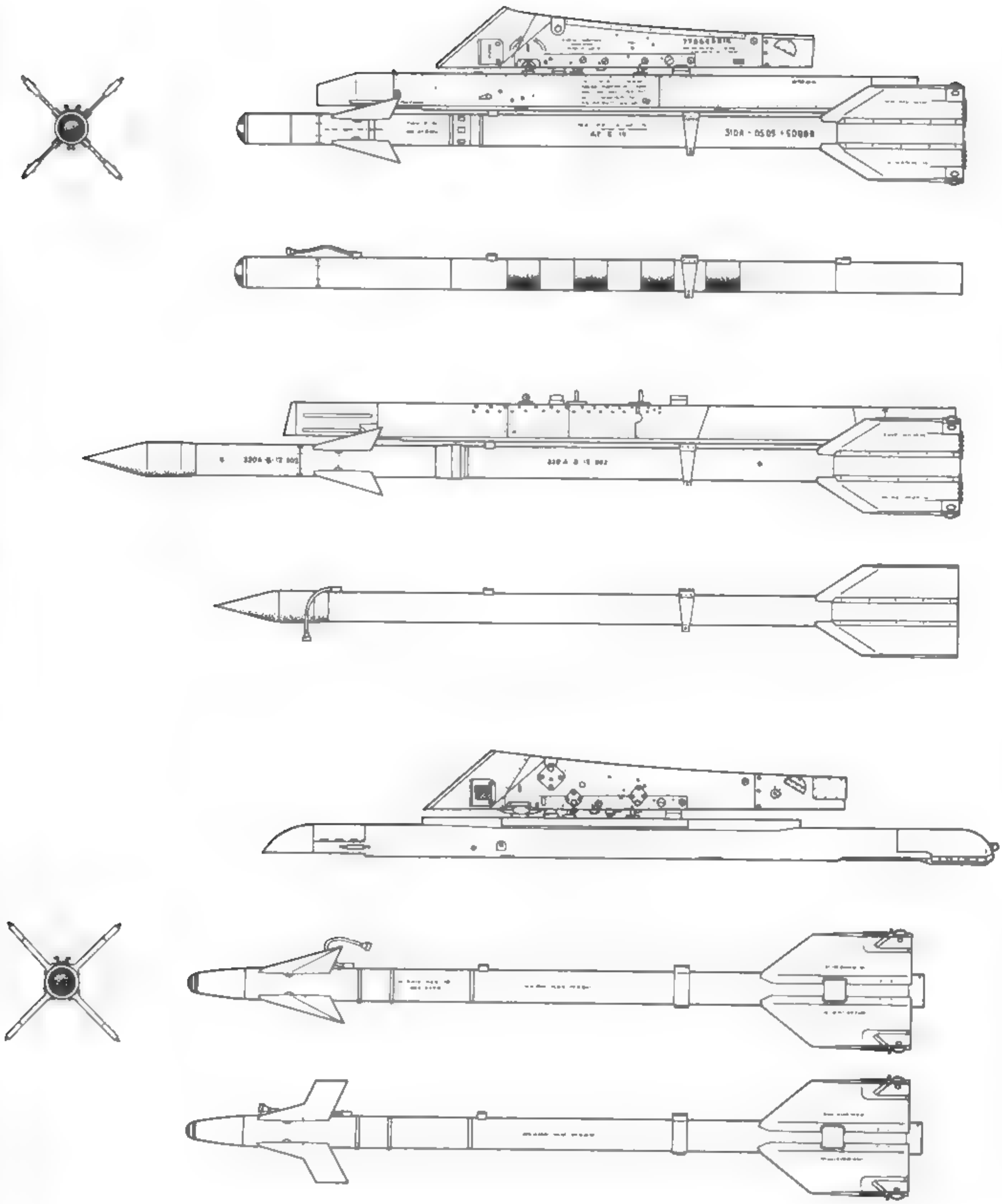
The rudder section is followed by the warhead and the radar proximity fuse The latter has a larger diameter than the missile's body, which results in a characteristic bulge amidships, the fuse's transmitter/receiver antennas are located in the thickest portion Further aft are the rocket motor and the fins

The R-3R is compatible with the APU-13U-2 launch rail Two or four such missiles can be carried by late MiG-21 versions (from the MiG-21S up to and including the MiG-21*bis*) and early versions of the MiG-23 (the MiG-23S and the export MiG-23MS version of the MiG-23M/MF)

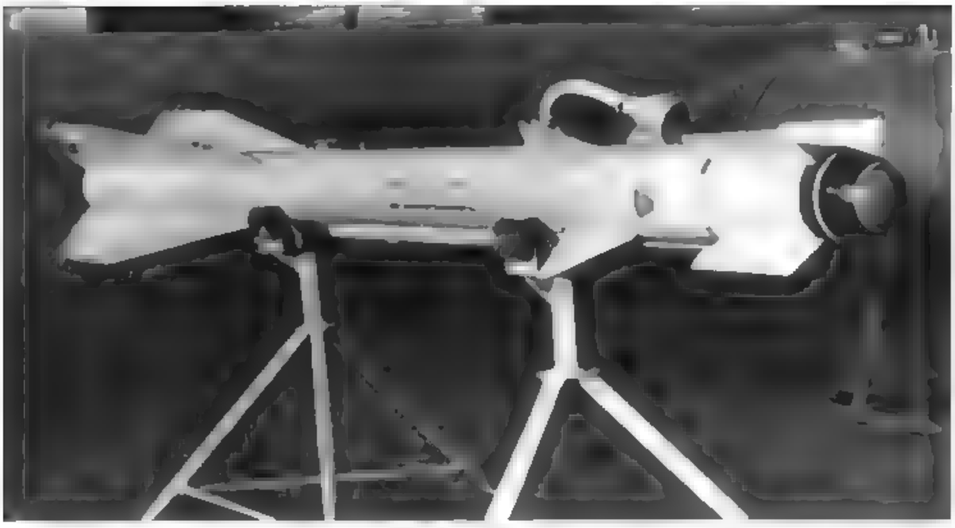
A fixed acquisition round designated R-3RU (*izdeliye* 328) was derived from the R-3R. It was similar to the R-3U in internal layout but had a radar seeker head (of course) and retained the live missile's fins

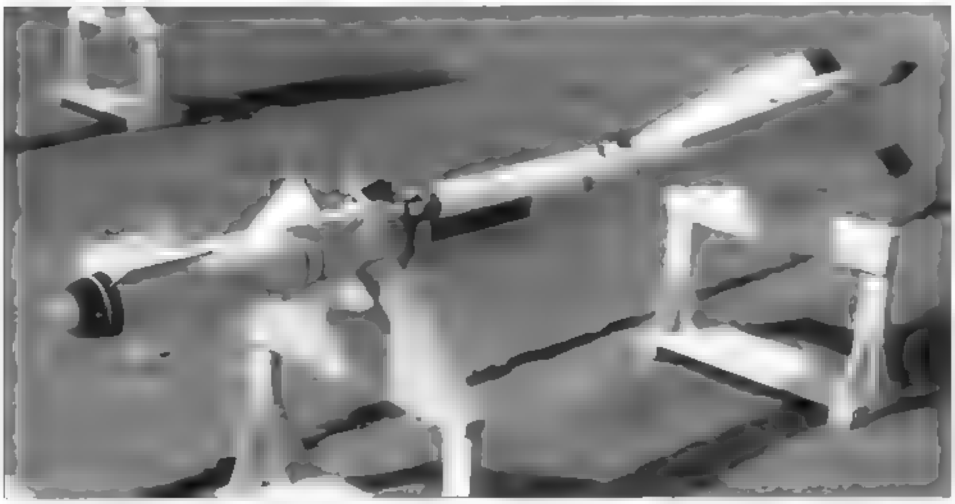


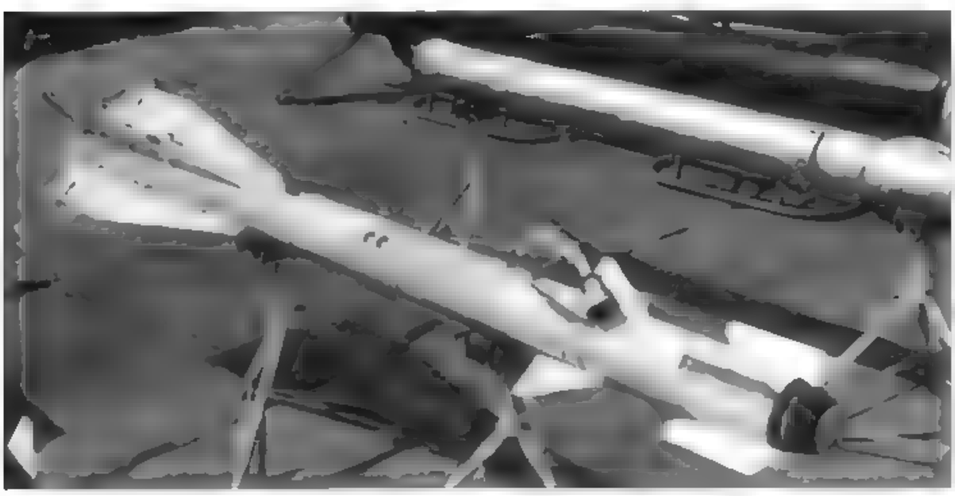
A drawing of the R-13M from a GMKB Vympel advertising leaflet



Top to bottom: An R-3S (K-13) on a BD3-60-21U launch rail, plus a rear view of the same missile, the R-3U fixed acquisition round, the R-3R (K-13R) on an APU-13U2 launch rail; the R-3UR fixed acquisition round, the BD3-60-21D launch rail (or BD3-60-23, which is outwardly identical), rear and side views of the R-13M (K-13M); and the R-13M1







(but not the rudders), except that no rollerons were fitted

R-13M (K-13M, *izdeliye* 380) air-to-air missile

The next stage in the R-3's evolution was the R-13M (*izdeliye* 380) designed for use in the same conditions as the R-3S in air-to-air mode (pursuit mode/clear weather). While being primarily a 'dogfight missile', the R-13M is also suitable for use against small ground targets with a high heat signature

The R-13M is similar in layout to the R-3S, except that the warhead and the proximity fuse were transposed. The stuff inside all of the missile's bays, however, is completely revised. Thus the R-13M has a new ***Iney-70*** (Hoar Frost-70) IR seeker head featuring a liquid nitrogen cooling system, a feature that increased its detection range twofold Both the fins and the rudders have greater span and area and feature thicker airfoils in order to improve agility. The *Sinitsa* (Tomtit) active proximity fuse is also new

The R-13M utilises a new-generation warhead of the so-called continuous rod type. The warhead bay houses a penetrator consisting of 144 metal rods whose opposite ends are welded together consecutively to form a chain When the explosive charge detonates, this chain expands into a ring 10 4 m (34 ft 1½ in) in diameter which slices into the target like a chainsaw

Despite being shorter, the rocket motor delivers almost twice the thrust of the R-3S's motor at 6,000 kgp (13 230 lbst). The burn time is 3.3-5.4 seconds and controlled flight time is 55 seconds

R-13M1 (*izdeliye* 380M) air-to-air missile

The aerodynamics of a missile's rudders vary considerably, depending on the altitude (that is, air density) and speed (that is, dynamic pressure). This, of course, affects the missile's manoeuvrability and guidance accuracy. In order to improve these crucial parameters the Bisnovat OKB developed a new version of the missile designated

Top left An R-60K short-range heat-seeking missile. The cable serves for transmitting the launch command from the fighter to the missile.

Centre left· This view shows the R-60K's fixed canards (destabilisers), the rollerons and the lateral aerials of the Kolibri radar proximity fuse.

Above left. This R-60 has a Strizh optical proximity fuse instead (note the paired 'viewing ports' amidships)

Left. The R-60K is a cutaway instructional round complete with a cutaway APU-60-1 launch rail and appropriate '*oochebno-razreznoye*' [*izdeliye*] stencils.

R-13M1 (*izdeliye* 380M). The missile features new trapezoidal rudders with moderate sweep over most of the span; the sweepback angle is optimised for low dynamic pressures. To improve efficiency at high speeds the rudders feature sharply swept leading-edge root extensions (LERXes); overall rudder area is increased somewhat. These measures have also enhanced rudder efficiency during high angle-of-attack manoeuvres. The rest of the structure and systems is similar to that of the R-13M, and the new missile is carried by the same aircraft as the latter type

R-60 (K-60, *izdeliye* 62) air-to-air missile

Developed in the early 1970s, the R-60 (*izdeliye* 62) short-range IR-homing missile pertains to a new class of aircraft weapons which has come to be called 'dogfight missiles'. Such missiles are characterised by

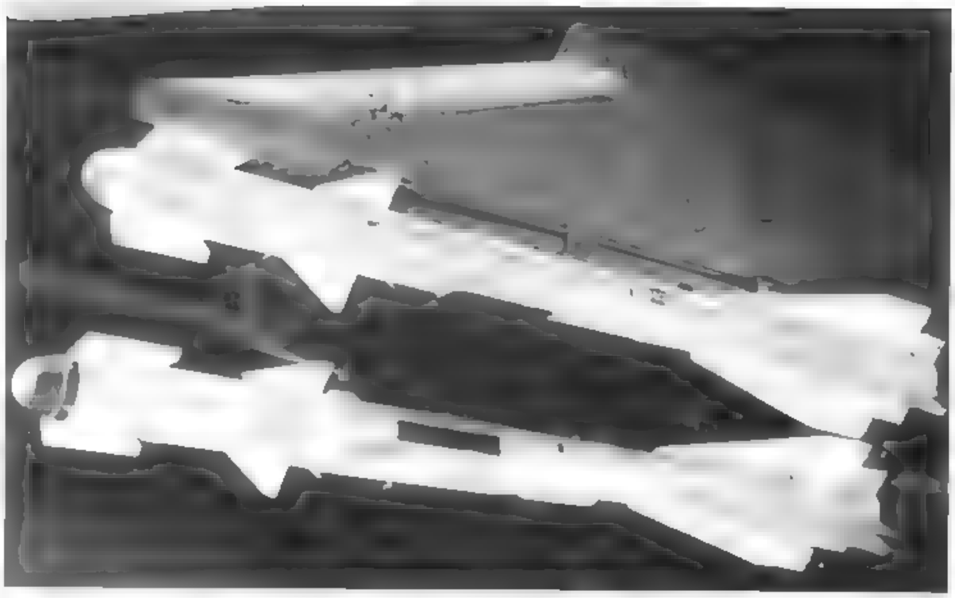
- a very short launch range not exceeding the effective gunnery range,
- high-G turns with lateral G loads approximately three times those of the target taking evasive action,
- low inertia of the missile and high angle speeds of the missile's IR seeker head as it tracks the target,
- low weight and small size enabling the aircraft to carry a large complement of missiles

The R-60 is designed for close-range air combat; it can be used against low-flying aircraft (that is, in 'look-down/shoot-down' mode) and ground targets with a high heat signature In its general arrangement the missile is a logical follow-on to the R-13, utilising a canard layout with cruciform fins and rudders; small fixed canard surfaces called destabilisers are installed ahead of the rudders to improve their efficiency at high angles of attack

The missile's body is built in five sections. Section 1 houses the Komar (Mosquito) IR seeker head with an uncooled optical element. This section carries the abovesaid destabilisers

Section 2 accommodates the high-explosive/fragmentation warhead, followed by the autopilot, automatic control module and contact detonator in Section 3. The latter carries the rudders whose actuators are powered by powder gases bled from the rocket motor

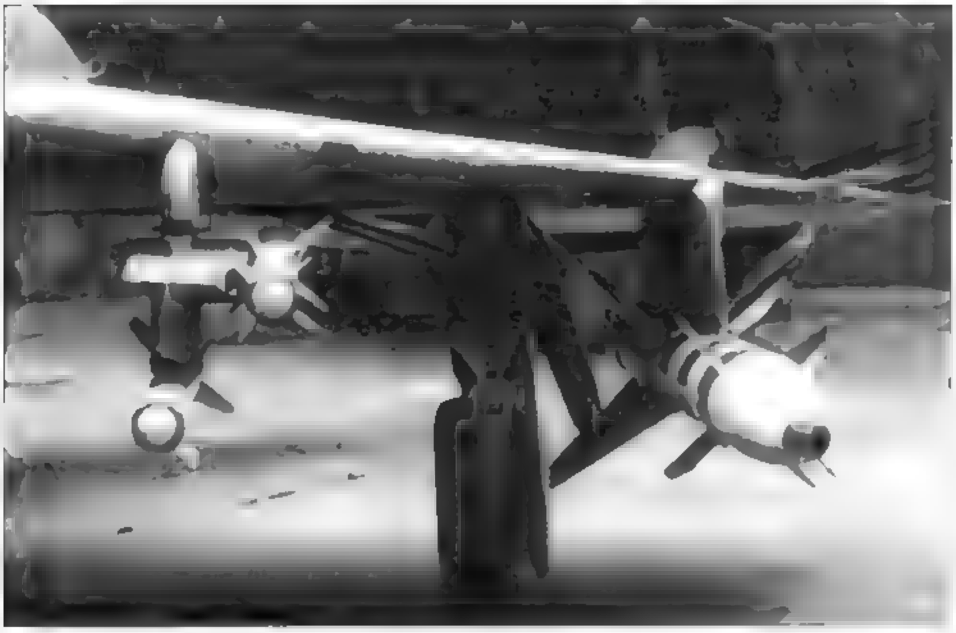
Section 4 houses the proximity fuse, a pressure accumulator and two turbine-driven generators, the pressure accumulator builds up powder gas pressure for the rudder actuators. The generators supplying electric power for the missile's systems are likewise powered by rocket motor bleed gases. A conduit housing bleed gas pipelines and electric wiring runs along the underside of Sections 3 and 4



Top right: R-60MK AAMs (that is, R-30Ms with Kolibri-M radar proximity fuses) on a paired APU-60-2 launcher on the port inboard pylon of a MiG-31 interceptor Note the different colour of the IR seeker heads.

Above right. R-60MKs on the other side. The APU-60-2 comes in non-interchangeable port and starboard versions

Right: Another view of the starboard-side APU-60-2. The ventral conduit of the outboard missile is clearly visible here, as are the rollerons on the trailing edges of the fins.



Left: This picture of an APU-60-2 with two R-60 missiles on the port inboard pylon of a Su-15 interceptor shows the shape of the launcher in front view; the angle between the two rails is less than 90° The big missile is an R-98MT.

Below left. The prototype of the MiG-23M (c/n 1007) armed with six R-60s – four live ones on APU-60-2s under the fuselage and two inert ones on APU-60-1s under the wing gloves.

In order to enhance the R-60's ECM resistance two alternative proximity fuses can be fitted. The Strizh (Swift) optical fuse is an active fuse Eight windows are located in opposite pairs around the circumference of the missile's body, concealing optical emitter and receiver lenses pointing forward at 75° to the direction of flight. The fuse detonates the warhead when the missile comes within 1-5 m (3 ft 3 in to 16 ft 5 in) of the target

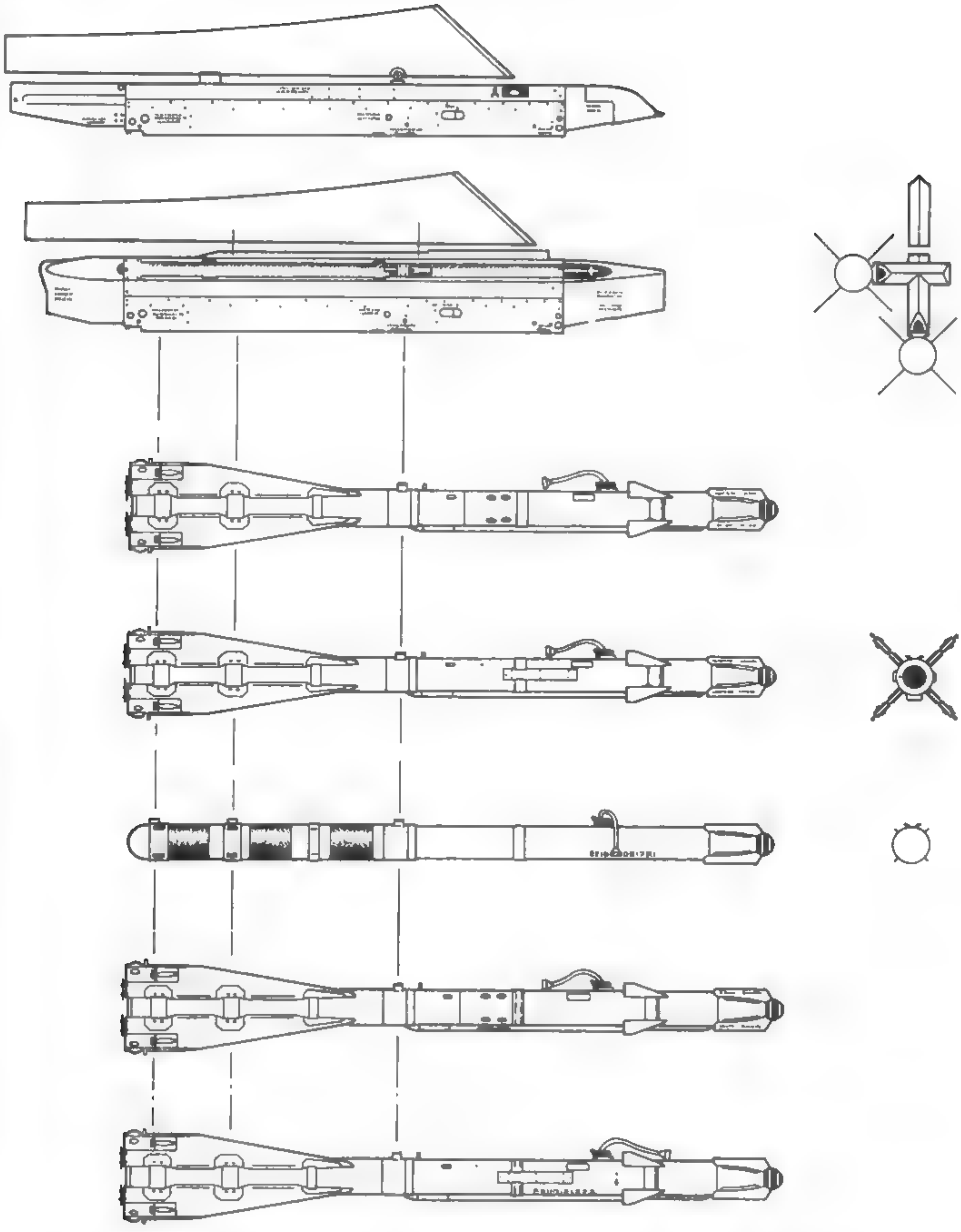
The *Kolibri* (Colibri) radar proximity fuse is likewise an active one, its external identification features are the flush antennas transmitting and receiving pulsed radio signals. The version of the missile fitted with this fuse is designated R-60K

Section 5 is a high-impulse solid-fuel rocket motor with a burn time of 3-5 seconds. The missile self-destructs in 25 seconds if it misses the target Section 5 carries trapezoidal fins equipped with rollerons three mounting lugs are provided on the upper side of the missile's body.

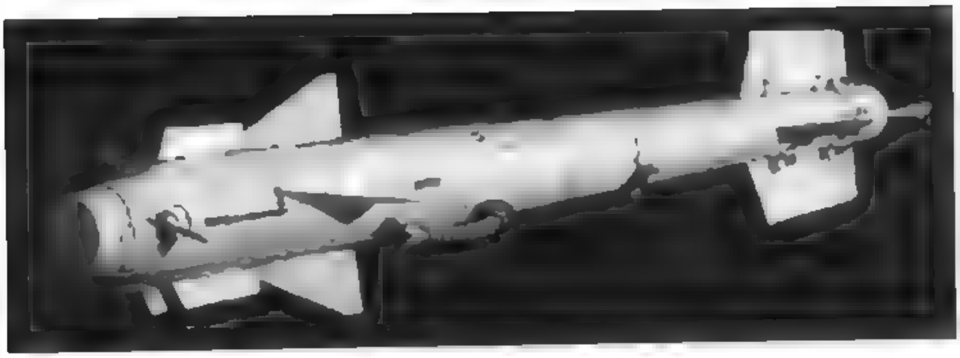
The R-60 is carried by the MiG-21*bis* and MiG-23M *et seq* tactical fighters, the MiG-25PD and Su-15TM interceptors, the

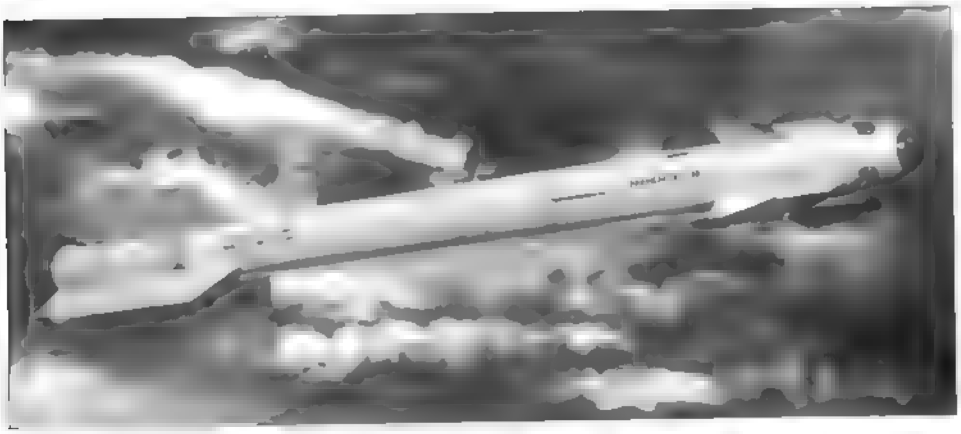
The following table gives the specifications of some of the Bisnovat OKB's short-range missiles.

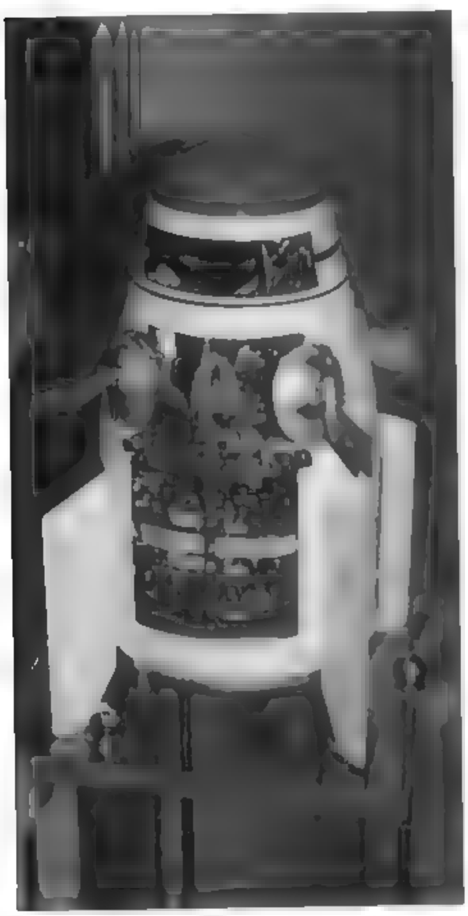
	R-3S (K-13)	**R-3R (K-13R)**	**R-13M (K-13M)**	**R-60 (K-60)**
Product code	*Izdeliye* 310A	*Izdeliye* 320	*Izdeliye* 380	*Izdeliye* 62
Codename				
US	AA-2A	AA 2C	AA-2D	AA 8
NATO (ASCC)	*Atoll*	*Atoll*	*Advanced Atoll*	*Aphid*
Service entry	1960	[illegible]	1972	1975
Calibre	127 mm (5 in)	127 mm (5 in	127 mm (5 in)	120 mm (4²⁹⁄₃₂ in)
Length overall	2 84 m (9 ft 3 ³⁄₁₆ in)	3 42 m (11 ft 2⁴⁄₆₄ in)	2 87 m (9 ft 5 in)	2 096 m (6 ft 10½ in)
Wing span	0.53 m (1 ft 8¾ in)	0 53 m (1 ft 8¾ in)	0 63 m (2 ft 0 ⁵⁄₃₂ in)	0.39 m (1 ft 3 ⁵⁄₁₆ in)
Launch weight, kg (lb,	75 3 (166 0)	82 4 (181 6)	88.2 (194.4)	43 5 (59 5)
Warhead weight kg (lb)	11 3 (24 9)	11 3 (24 9)	11.3 (24.9)	2.7 (18.96)
Kill range, km (miles)	1-3.6 (0 62-2 23)	1 3 6 (0 62 2 23)	0.9-4.0 (0.55-2 48)	0.25-1.0 (0.15-0.62)
Kill altitude, m (ft)	0-21 500 (0-70,540)	1 000 21 500 (3 280 70 540)	0-22 000 (0-72,180)	0-20,000 (0-65 615,
Launch rail type	APU-13 APU-13U-1 APU 13MT	APU-13U 2	APU 13MT	APU 60-1 APU-60 2
Missile platform	MiG 21F-13 MiG-19P (1965 upgrade) MiG-21PF thru MiG 21*bis* MiG-23 MiG-23S MiG-23M Su-20	MiG-21S thru MiG 21*bis* MiG 23 MiG 23S MiG 23MS	MiG-21SM thru MiG 21*bis*, MiG 23 MiG 23M MF	MiG-21*bis* MiG-23M thru MiG-23MLD, MiG-25PD, Su-15TM Su-25 Su-17M3/Su-17M4 Yak-38

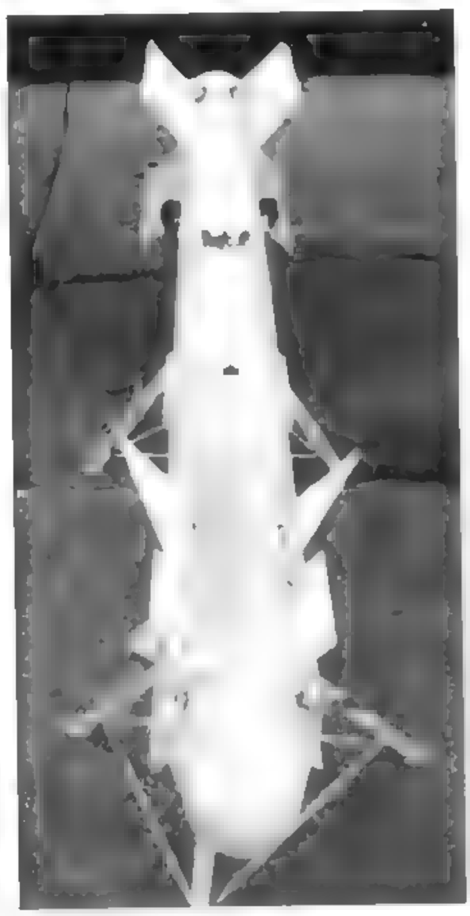


Top to bottom The APU-60-1 launch rail, the APU-60-2 paired launcher (starboard side version), the R-60 with a Strizh optical proximity fuse, the R-60K with a Kolibri radio proximity fuse (plus rear view), the UZR-60 fixed acquisition round, the R-60M with a Strizh optical proximity fuse, and the R-60MK with a Kolibri-M radio proximity fuse.









Top: The R-73 short-range AAM is strongly reminiscent of the earlier R-60M but has a different fin shape and very characteristic pitch/yaw vanes immediately ahead of the destabilisers

Centre: This view shows the R-73's inset ailerons

Above left: A cutaway example of the R-73's IR seeker head showing the pitch yaw vanes in close-up. These are not found on some R-73s; the version with vanes is sometimes called R-73RMD.

Su-17M3/Su-17M4 fighter-bombers, the Su-24M tactical bomber, the Su-25 ground-attack aircraft, the Yak-38 vertical take-off and landing shipboard strike aircraft and other types. The APU-60-1 single missile rail and the APU-60-2 twin missile launcher have been specially developed for this weapon. The latter model is a T-section structure on which one missile is carried ventrally and the other outboard, it comes in port and starboard side versions which are non-interchangeable. The APU-60-1 missile rails are usually carried on BD3-60-23K1 underwing pylons; the MiG-23M and subsequent versions can also carry APU-60-1 rails under the fuselage on BD3-60-23F1 pylons.

A fixed acquisition round based on the R-60 was developed and manufactured as the UZ-62 (also referred to as UZR-60); it fulfils the same mission as the R-3U and, like the latter round, lacks fins and rudders. The UZ-62 has a data recorder in lieu of a warhead and ballast instead of the rocket motor.

R-60M (*izdeliye* 62M) air-to-air missile

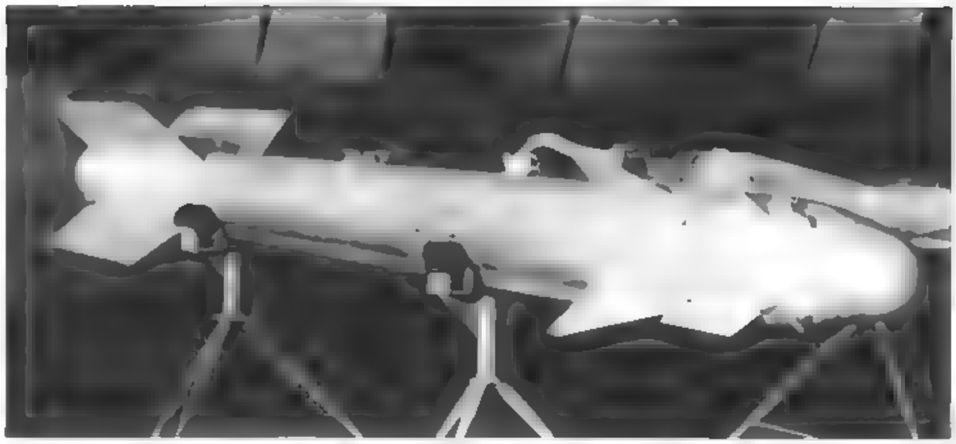
The R-60M (*izdeliye* 62M) 'dogfight missile' is a more refined version of the R-60. Performance is improved thanks to the more effective IR seeker head, a more lethal warhead and a proximity fuse with better ECM resistance. The upgraded seeker head offers enhanced guidance accuracy at close range thanks to the higher closing rate limit.

Structurally the airframe was almost unchanged, except for Section 2 which was lengthened by 42 mm (1²⁷⁄₃₂ in) to accommodate a new continuous rod warhead. The launch weight is 45 kg (99 lb).

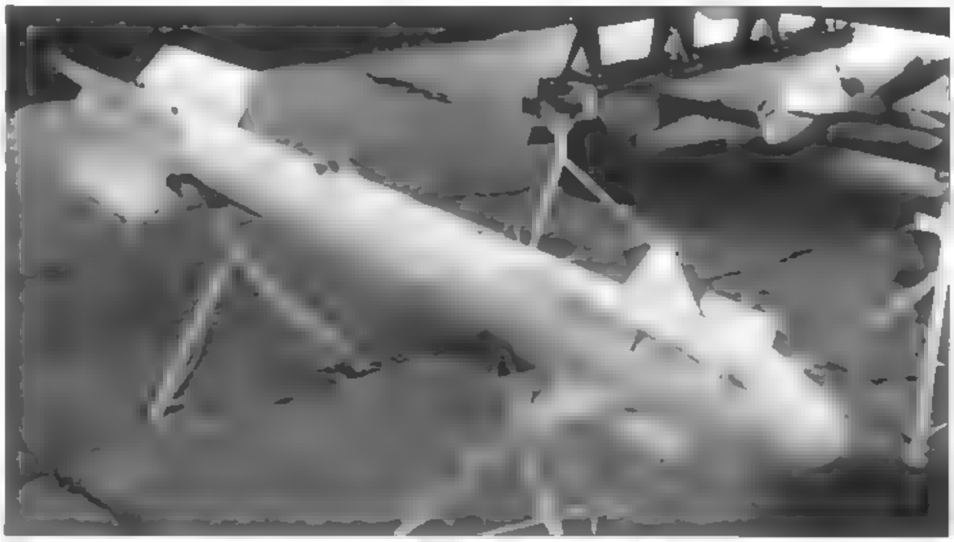
Like the baseline version, the R-60M is produced in two versions featuring a Strizh optical proximity fuse or a Kolibri-M radar proximity fuse; the latter version is designated R-60MK. An R-60MU acquisition round broadly similar to the UZ-62 is also produced. The R-60M is carried by the same aircraft types as the R-60 *sans suffixe*.

R-73 and R-73E air-to-air missiles

The R-73 third-generation missile is the world's first AAM to combine the features of short-range missiles and 'dogfight missiles'. It was developed primarily for air superiority fighters – first and foremost fourth-generation aircraft such as the MiG-29 and Su-27 and their derivatives. It is a true 'wish 'em dead' missile, one of the R-73's greatest merits is that it does not hamper the aircraft's manoeuvrability in a dogfight – an important factor, now that super-agility is strongly on the agenda. Experts judge the R 73 to be superior to all Western counterparts – the MATRA Mica, MATRA Magic 2, NWC AIM 9M, AIM-9C and BAe ASRAAM.



Right: An R-73 on display during one of the 'open doors days' at Kubinka AB, showing the connecting cable.



Below right and foot of opposite page A longer-range version of the R-73 designated R-73E is identifiable by the longer-burn rocket motor protruding beyond the trailing edges of the fins. No connecting cable is fitted to this one.

The R-73 is also the world's first missile to make use of a combined aerodynamic/reaction control system enhancing the missile's agility. It enables high-G dogfighting around the clock involving attacks from any direction, including attacks in 'look-down/shoot-down' mode, in an active ECM environment; it enables 'shoot on sight' attacks on the spur of the moment and makes it possible to implement the 'one shot, one kill' principle. In a dogfight the R-73 does not impose any limits on the fighter's manoeuvring G loads, flight altitude and speed; thus the pilot is free to choose the most advantageous tactic.

The R-73 can lock on to targets within a 120-degree cone and pull as many as 40-50 Gs in a manoeuvre while tracking a target which is taking violent evasive action; it is capable of destroying targets making evasive manoeuvres up to 12 Gs. Moreover, the missile is capable of making a U-turn immediately after launch to engage a target pursuing the aircraft; however, this requires the fighter to be equipped with a tail protection system enabling targeting in the rear hemisphere.

The missile's seeker head can receive target information from a helmet-mounted sight, such as the Shchel-4UM issued to MiG-29 pilots. The HMS can acquire targets within a cone of ±60° from the missile's axis of symmetry, which allows the pilot to aim his weapons by merely turning his head without altering the direction of flight ('point and shoot'). Looks can kill - literally.

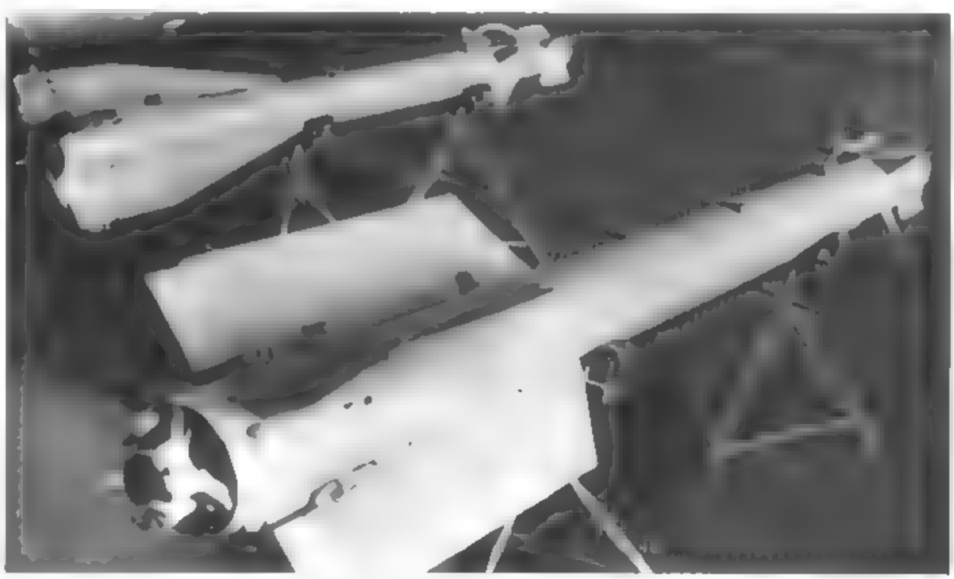
The R-73 is/was on the inventory of the Russian Air Force and the air arms of Germany, Yugoslavia (now reduced to Serbia and Montenegro), Syria, India, Iraq and North Korea. Most of the MiG-29 fighters in service worldwide are armed with R-73 missiles. In 1994 several US Air Force Lockheed Martin F-16 Fighting Falcons of the 510th Fighter Squadron stationed at Aviano AB, Italy, had a dissimilar air combat training (DACT) session with Luftwaffe MiG-29s. This gave the USAF some experience of close-in dogfighting against aircraft armed with R-73 AAMs.

The R-73 is 2.9 m (9 ft 6 11/64 in) long, with a body diameter of 170 mm (6 11/16 in) and a wing span of 0.51 m (1 ft 8 in). The launch weight is 105 kg (231.5 lb), including a 8-kg (17.6-lb) continuous rod warhead; the permissible launch range is 0.3-30 km (0.18-18.6 miles) and the maximum target altitude is 20,000 m (65,620 ft).

A longer-range version of the R-73 was developed as the R-73E, the suffix standing for *energovo'oroozhonnaya* (= 'high-powered'). It differs only in having a longer-burn rocket motor which increases the launch weight to 110 kg (242.5 lb) and the maximum 'kill' range to 40 km (24.7 miles). It also increases the missile's length somewhat.

R-73M air-to-air missile

In the mid-1990s GMKB Vympel was completing development of a thoroughly



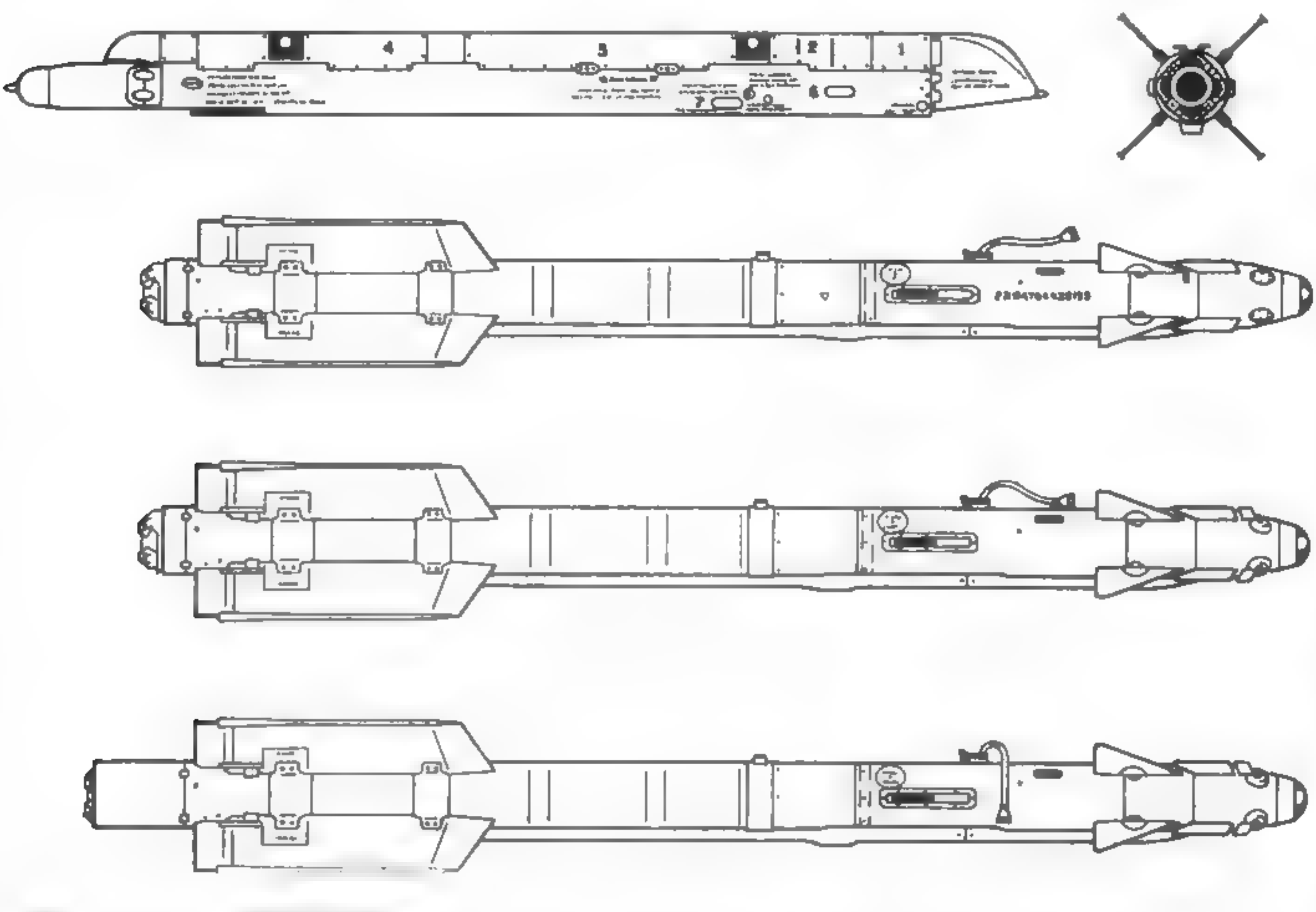
This picture illustrates clearly the external differences between the R-73 (foreground) and the R-60M. It also shows clearly the R-73's reaction control paddles around the rocket motor nozzle giving the missile incredible agility.

Left: Two black-striped dummy R-73s on the two outer port side missile rails of the Su-27SMK prototype ('305 Grey'). Note the differently shaped rear ends of the outer (wingtip) and inner P-12-1D launch rails.

upgraded version of the R-73; designated R-73M (*modernizeerovannaya* – updated), the missile was due for inclusion into the Russian Air Force inventory by the end of 1996 The R-73M features a new multi facet IR seeker head with an improved digital signal processor featuring two operating frequencies, the seeker head has twice the sensitivity as compared to the original R-73, R-73E and enables target lock-on within a 180° field of view Again, the missile has a combined aerodynamic/reaction control system but a vectoring nozzle is used instead of the previous model's deflector 'paddles'; this enhances agility considerably, allowing the R-73M to pull up to 50 Gs in a manoeuvre

The R-73M is to be equipped with a built-in electronic counter-countermeasures (ECCM) system utilising four different methods of neutralising enemy ECM/infra-red countermeasures (IRCM) The system incorporates an algorithm allowing the missile to go for the centre section of the target aircraft's fuselage instead of the hottest part (the engine nozzle) at the terminal guidance phase, thereby reducing the target's chances of evading the missile

Structurally the R-73M differs in having shorter-span fins, a feature that eliminates or minimises the missile's oscillations after leaving the launch rail The missile's launch weight is increased by 5 kg (11 lb) in comparison with the R-73 but the kinetic range is doubled, and the R-73M is to be superior in turning speed to the BAe ASRAAM



Top to bottom: The P-12-1D launch rail (the version for underwing installation) the R-73 without pitch/yaw vanes (plus rear view), the R-73 with pitch/yaw vanes (R-73RMD); and the R-73E

Right: The K-8 missile was tested on two Yak-25K-8 weapons testbeds. The two missiles were carried on long pylons installed inboard of the engine nacelles. The large size of the K-8 is pretty obvious in this view.

Below right: Front view of the K-8 under the port wing of a Yak-25K-8 (probably c/n 0119). Note the pylon bracing strut on the inboard side and the sway braces propped up against the missile's fins.

Bottom right: Rear view of the missile on the other side. The rocket motor nozzle is blanked off, identifying the missile as a dummy

The R-73M successfully passed its trials programme, using the Su-27 interceptor as a launch platform. All stock R-73s can be upgraded to R-73M standard

The medium-range AAMs

Development of these weapons got under way in the mid-1950s with dedicated interceptors in mind, such as the Su-11, Mikoyan/Gurevich I-75 and others. From the mid-1960s onwards the medium-range AAMs were used on new-generation multirole fighters as stand-off weapons

R-8 (K-8) air-to-air missile

In the mid-1950s the Soviet Ministry of Defence issued a request for proposals (RFP) for a new homing air-to-air missile intended for new-generation heavy interceptors, including the Mikoyan/Gurevich I-75 and the Sukhoi T-47 (known as the Su-11 in service). The Bisnovat OKB emerged as the winner in the ensuing contest with the K-8 project. Developed and perfected within a remarkably short time, the missile (known as the R-8 in production form) joined the inventory as part of the Su-11-8M aerial intercept weapons system, it was the first Soviet homing AAM to achieve production status

The K-8 (R-8) is a 275-mm (10$^{53}/_{64}$ in) missile designed for attacking all kinds of aerial targets in pursuit mode. During the attack the interceptor has to stay below the target's flight level in order to prevent ground clutter from disrupting missile guidance. To improve the weapons system's resistance to ECM and ground clutter the missile was developed in two versions: the semi-active radar homing R-8R (for ***r**adiolokatsionnaya* [*golovka **s**amonave**den**iya*] – radar seeker head) and the heat-seeking R-8T (for ***t**eplovaya* [*golovka **s**amonave**den**iya*] – IR seeker head). The two are identical, except for the foremost body section; both versions can be carried simultaneously by the same aircraft

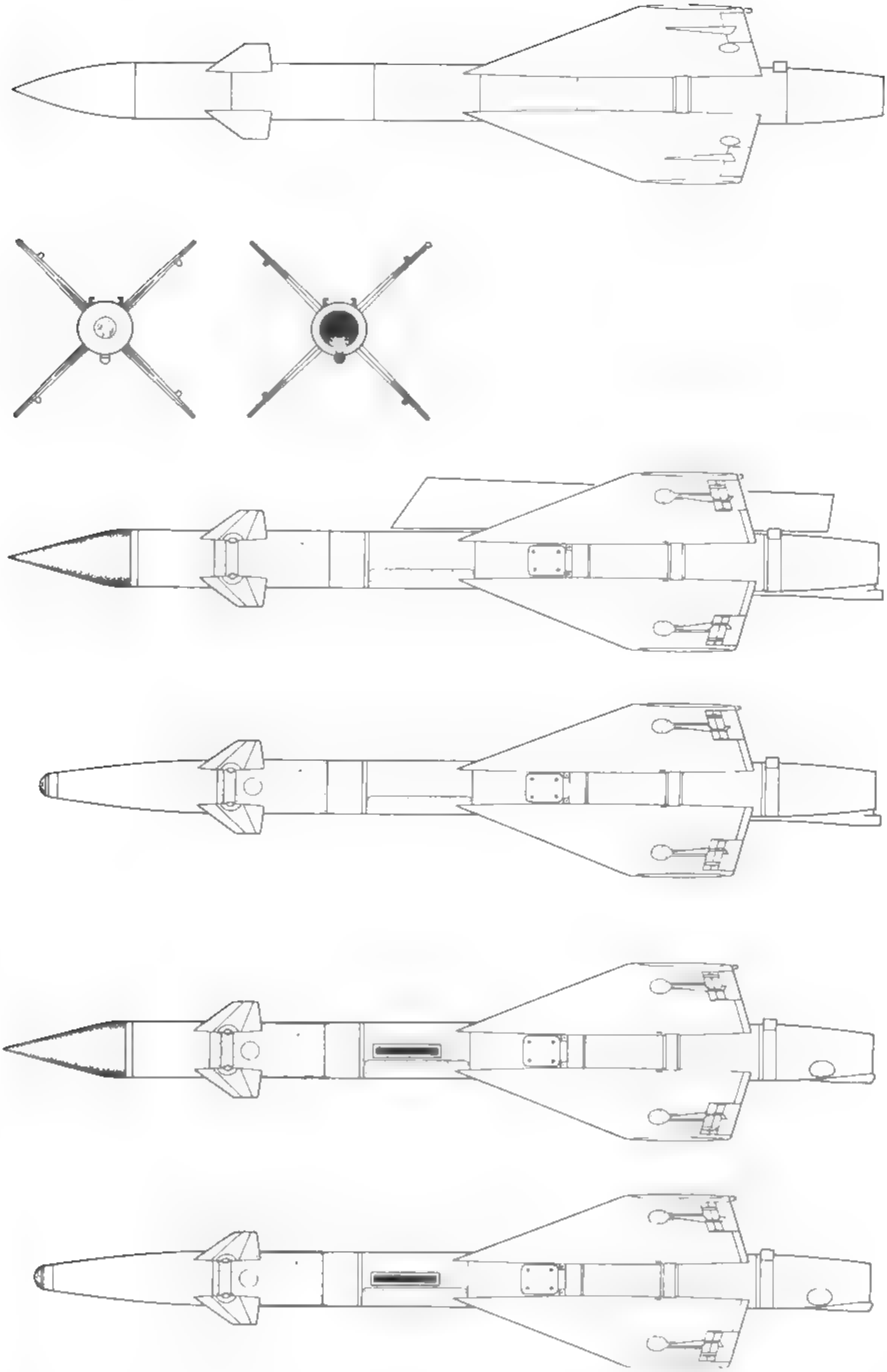
The R-8 utilises a canard layout with cruciform fins and rudders which allow the missile to make any manoeuvre without banking. The missile is powered by a solid-fuel rocket motor having a single axisymmetrical nozzle

Above: Another experimental fighter that carried the K-8 missiles was the Mikoyan Gurevich I-75 interceptor This view shows the armament installation on this large aircraft; the missiles are probably dummies again.

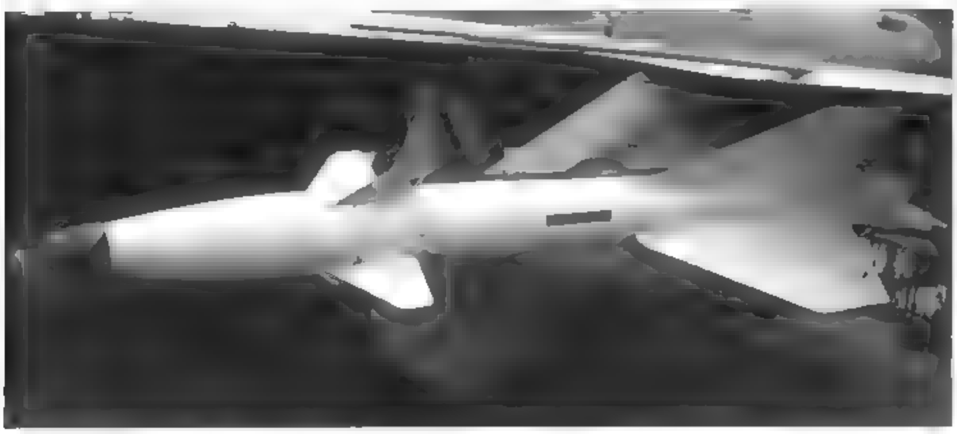
The missile's body is built in four sections Section 1 houses the seeker head, its shape and length (and hence the missile's overall length) varies, depending on the version. The R 8R has a PARG-16 semi-active radar seeker head (*poluaktivnaya rahdiolokatsionnaya golovka*) enclosed by a dielectric radome. It works in conjunction with the missile's autopilot and the interceptor's fire control radar, receiving the radar echo and feeding the signal to the autopilot which controls the rudders, maximum target lock-on range is about 20 km (12.4 miles) To ensure guidance the target needs to be illuminated by the interceptor's radar all the way from launch to detonation. The R-8T features a TGS-14 IR seeker head (*teplovaya golovka samonavedeniya*); it performs the same function but continuous target illumination is not required

Section 2 is divided into three bays, the foremost of which houses the autopilot and the pneumatic control actuators, the autopilot works both the canard rudders and the

The tenth production Su-11 interceptor ('10 Red', c/n 0115310) with a pair of IR-homing R-8MT missiles.



Top to bottom. A mock-up of the K-8 missile; front and rear views of the R-8T; the R-8R; the R-8T; the R-8MR (R-8M1R), and the R-8MT (R-8M1T).



Left: A red-painted inert example of the radar-homing K-98MR (R-8MR). Note the flush aerial of the radio proximity fuse and the deflection of the rudder pairs to create yaw to the right.

Below: The R-8 evolved into the R-98 and the R-98M. This is a radar-homing R-98MR under the port wing of a Su-11; note the thicker and longer tail section carrying strake aerials.

ailerons. The front part of Section 2 carries the rudders and the two transmitter aerials of the *Aist-24* (Stork-24) radar proximity fuse located dorsally and ventrally opposite each other. Further aft is the high explosive/fragmentation warhead with a ventral access panel. The rearmost bay of Section 2 accommodates automatic electric control equipment and the aileron actuators.

Section 3 houses the PRD-141 solid-fuel rocket motor (*porokhovoy raketnyy dvigatel'*) with an extra-long nozzle – almost like an extension jetpipe on an aircraft. The body of this section is a load-bearing structure incorporating the wing attachment fittings and mounting lugs. The PRD-141 delivers an initial impulse of 11,200 kgp (24,690 lbst) which allows the R-8 to exceed the missile platform's speed by up to 500 m/sec (1,800 km/h, or 1,118 mph). At 18,000 m (59,055 ft), the missile's top speed at burnout is 1,015 m/sec (3,650 km/h, or 2,267 mph); at 200 m (660 ft) it is 690 m/sec (2,480 km/h, or 1,540 mph). The burn time is anywhere between 2.5 and 6.5 seconds, the missile self-destructs 40-60 seconds after launch.

Section 4 is a jetpipe fairing. It carries a ventrally mounted tracer enabling visual tracking during night launches.

The trapezoidal wings set at 45° to the horizontal plane have 60° leading-edge sweep and 11° reverse sweep on the trailing edges. They are two-spar stressed-skin structures, the torsion boxes are filled with Styrofoam. The trailing edges are occupied by ailerons controlled via a system of internal and external push-pull rods. The port upper wing incorporates a waveguide and a tip-mounted receiver aerial serving the radar seeker head.

The R-8 was put through its paces on the I-75, T-47, Yak-25K-8 and Yak-27K-8, and a small production batch was manufactured for these aircraft. Eventually, however, when the T-47 (Su-11) was cleared for production and service as part of the Su-11-8M weapons system, it was armed with improved R-8M missiles described below.

Above left. An IR-homing R-8MR on the port wing pylon of Su-15TM '11 Yellow' (c/n 1029). Note the IR seeker head with protective cap, the lateral proximity fuse aerials and the narrow tail section with a ventral tracer.

Left: Here, for comparison, is an R-98MT under the wing of a Su-15TM.

Above: A Su-15TM coded '15 Yellow' with a typical weapons load – an R-98MT to port, an R-98MR to starboard and two UPK-23-250 cannon pods under the fuselage. An identically configured example shot down Korean Air Lines Boeing 747-230B HL7442 over the Sea of Japan on the night of 1st September 1983

Right: A late-production Yak-28P with two inert R-8M1 missiles on approach to a Soviet airbase in (former) East Germany.

R-8M air-to-air missile (R-8MR/*izdeliye* 24R; R-8MT/*izdeliye* 24T)

Derived from the R-8 AAM, the R-8M (*modifitseerovannaya* – modified) became the progenitor of a whole family of missiles in the same class and having the same calibre (the R-8M1, R-98, R-98M and so on). Entering large-scale production in 1961, the R-8M was initially the standard weapon of the Su-11; later it found use on the Su-15 and Yak-28P interceptors

The missile shares the aerodynamic layout and structural design of the R-8. Like the latter, it was produced in two versions differing in guidance system type: the semi-active radar homing R-8MR (*izdeliye* 24R) and the heat-seeking R-8MT (*izdeliye* 24T). To increase the 'kill' probability the R-8M features two sets of opposed transmitter aerials for the radar proximity fuse on Section 2 instead of one, the lateral aerials are located further aft than the dorsal/ventral pair

When carried by the Su-11, the R-8MR/R-8MT enables destruction of targets flying at 5,000-23,000 m (16,400-75,460 ft) and up to 1,800 km/h (1,118 mph) within ranges of 2-12 km (1.24-7.45 miles). There is a requirement that the target should be flying at least 5,000 m above the interceptor's own flight level

R-8M1 air-to-air missile (R-8M1R, R-8M1T)

The next version of the R-8 AAM, the R-8M1 was developed for two new aerial intercept weapons systems with different operational altitudes: based on the Yak-28P and the Su-15, these were designed for low/medium and medium/high altitudes respectively. This artificial narrowing of the weapons systems operational envelope to suit the altitudes at which the aircraft in question was most efficient served to increase guidance accuracy and hence 'kill' probability

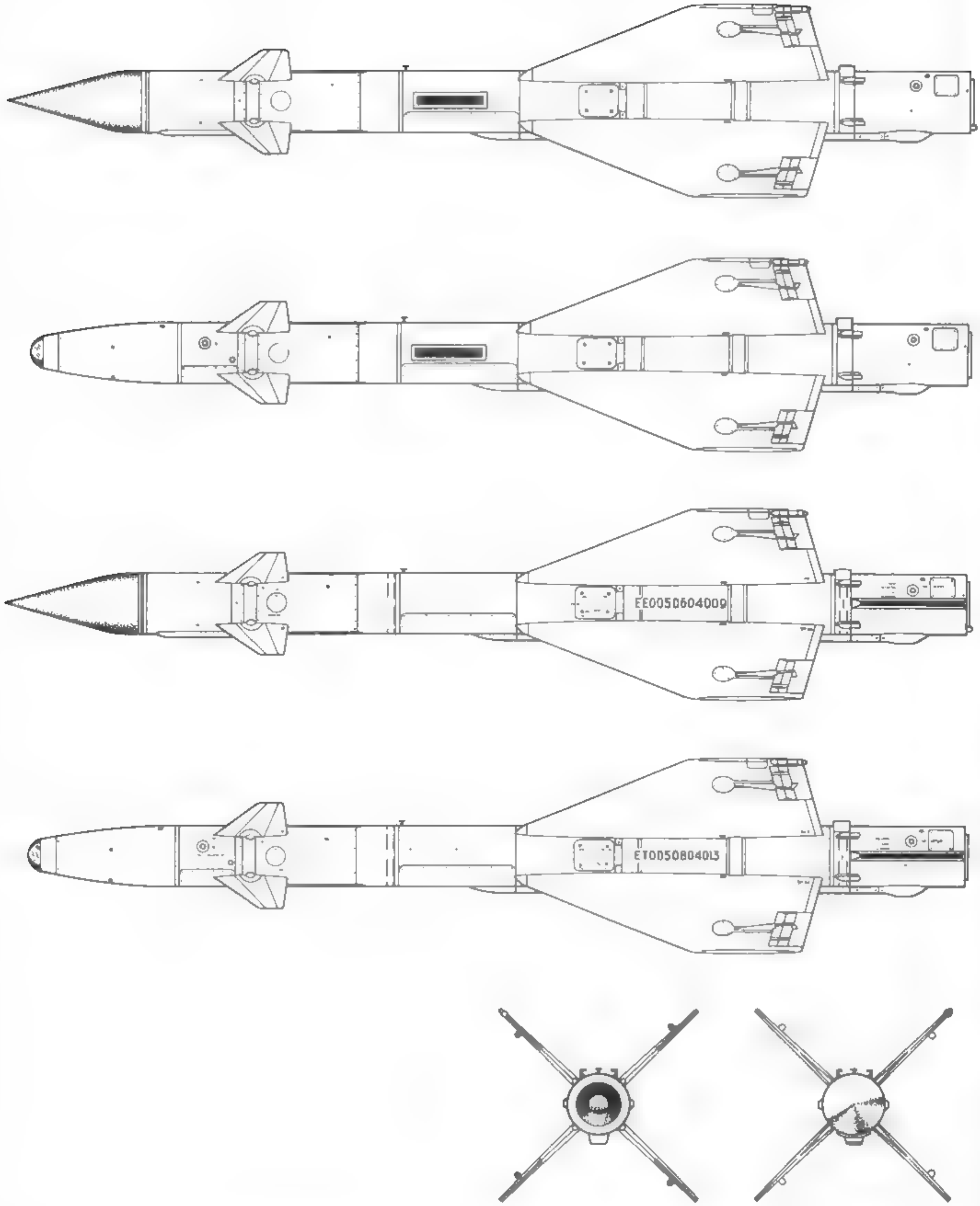
Outwardly the R-8M1 is indistinguishable from the preceding version. Yet it has a wider operational altitude envelope ranging from 300 to 23,000 m (980-75,460 ft), that is, a much lower minimum launch altitude. this is thanks to an upgraded autopilot and improved seeker heads. The new autopilot allows the control system parameters to be set in accordance with two alternative launch altitude ranges (that is, for different missile platforms) in a similar manner to the RS-2-US. The new IR seeker head gives the missile round-the-clock capability

Changes have also been made to the airframe. The R-8M1 features reinforced wings enabling the missile to absorb the higher G loads experienced during low-altitude operations

The R-8M1 entered production in 1963. Once again it was built in two versions – the radar-homing R-8M1R and the IR-homing R-8M1T

R-98 (K-98) air-to-air missile (R-98R/*izdeliye* 56R; R-98T/*izdeliye* 56T)

The R-98 AAM is a direct descendant of the R-8M1. Once again it comes in SARH and IR-homing versions designated R-98R (*izdeliye* 56R) and R-98T (*izdeliye* 56T) respectively. The missile's main distinguishing feature is all-aspect engagement capability: the R-98 can be used in head-on



Top to bottom The R-98R; the R-98T; the R-98MR, the R-98MT; a rear view of the R-98MT, and a front view of the R-98MR

mode. During attacks in pursuit mode the R-98's performance is identical to that of the R-8M1, in a head-on engagement the missile can take out a target doing up to 1,200 km/h (745 mph) at 2,000-18,000 m (6,560-59,055 ft) and up to 3,000 m (9,840 ft) above the interceptor's own flight level

Again, the R-98 owes its enhanced combat potential to upgrades done to the autopilot, seeker heads and proximity fuse The modified autopilot has considerably reduced the stabilisation system's reaction time and enabled the control system to switch between algorithms for head-on and pursuit modes The appropriate control system algorithm is selected by the fighter pilot prior to launch. The Aist-56 radar proximity fuse also features changes allowing its operation to be adjusted to the attack mode

The changes have affected the missile s appearance very little in comparison with the R-8M1 The R-98 differs from the latter in having a reshaped rear fairing (which is perfectly cylindrical, not tapered), a ventral wiring/pneumatic piping conduit and altered wings with a rounded leading edge at the roots. The rear fairing accommodates air bottles locate round the rocket motor nozzle, these contain compressed air for the missile's control system, hence the additional pipelines.

Another identification feature (characteristic of the R-98T only) is the ventral fairing on the forward section of the body The R-98T is equipped with a new TGS-14T infrared seeker head having all aspect, day/night engagement capability, with an attendant change in the shape and size of the foremost body section. The latter is divided into two bays housing the seeker head proper and its liquid nitrogen cooling system

Another difference (which is not so obvious) lies in the powerplant The R-98 is powered by a new PRD-143 solid-fuel rocket motor whose initial impulse is increased to 13,400 kgp (29,540 lbst)

In 1967 the R-98 missile joined the PVO inventory as part of the Su-15-98 aerial intercept weapons system built around the initial production Su-15 *sans suffixe* featuring the Oryol-D (Eagle-D) fire control radar The same missile was planned for the Su-15T equipped with the *Taifoon* (Typhoon) fire control radar, but this aircraft remained in prototype form

R-98M air-to-air missile (R-98MR/*izdeliye* 57R; R-98MT/*izdeliye* 57T)

As the Su-15 interceptor evolved, so did the R-98 missile. The next version was, logically enough, designated R-98M and came in SARH and IR-homing versions designated R 98MR (*izdeliye* 57R) and R 98MT (*izdeliye* 57T) respectively The R 98M was created for a new aerial intercept weapons system whose core was the Su-15TM interceptor featuring the Taifoon-M radar, it is an all-weather missile with round-the-clock/all-aspect engagement capability

As part of the weapons system, the R 98MR is capable of engaging targets at 2,000-21,000 m (6,560 68,900 ft) in head-on mode and 500-24,000 m (1,640-78,740 ft) in pursuit mode, the target can be up to 6,000 m (13,120 ft) above the interceptor's flight level The target's speed in these cases is 500-2,500 km/h (310-1,552 mph) and 500-1,800 km/h (310-1,118 mph) respectively Maximum 'kill' range is 24 km (15 miles) for an attack in head-on mode and 16 km (10 miles) in pursuit mode. The R-98MT ensures the same attack parameters, but in pursuit mode only

Outwardly the R-98MR/MT is distinguishable from the R-98R/T by the slightly different location of the proximity fuse's transmitter aerials, two of which are relocated from the centre part of the body (Section 2) to the tail fairing

Apart from the Su-15TM, the R-98M is compatible with Su-15 *sans suffixe* interceptors upgraded by installing an Oryol-D-58M radar as part of the Su-15-98M weapons system

R-23 air-to-air missile (R-23R/*izdeliye* 340; R-23T/*izdeliye* 360)

The Bisnovat OKB started work on the R-23 AAM in the early 1960s. Appropriately enough, the missile was intended for the new-generation MiG-23 fighter – a designation that was consecutively used for three totally different aircraft. First it was the ill-fated Ye-8 derived from the MiG-21, then the all-new delta-wing '23-01' aircraft (unofficially dubbed MiG-23PD; NATO reporting name *Faithless*) with a main cruise engine and three lift-jets for short take-off and landing - which again remained in prototype form – and finally the '23-11' with variable geometry wings which entered production as the MiG-23S *Flogger-A*.

The main criteria which the new missile had to meet were long range, high agility and all-aspect engagement capability In order to reduce development time OKB-4 chose the R-4 missile, which had only just

The following table gives the specifications of some of the Bisnovat OKB's medium-range missiles.

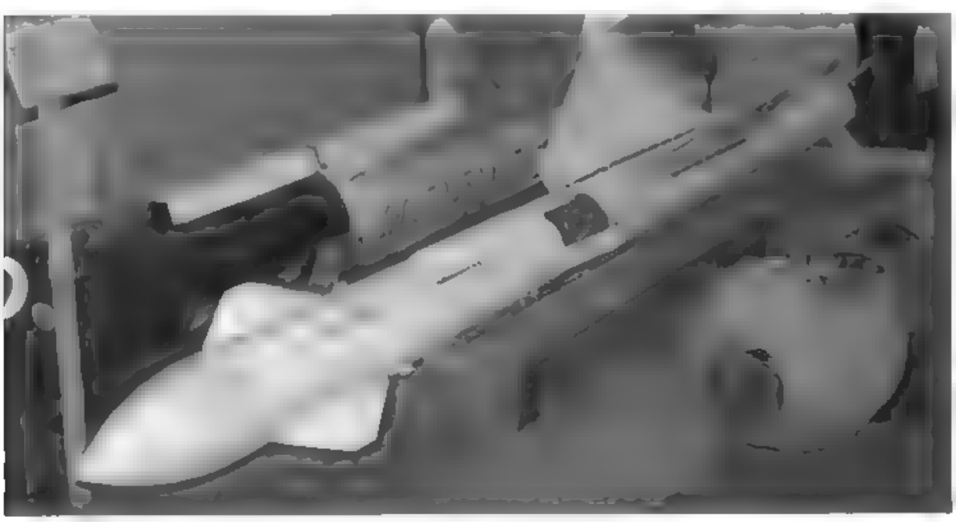
	R-8MR	R-8MT	R-98R	R-98MT
Product code	*Izdeliye* 24R	*Izdeliye* 24T	*Izdeliye* 56R	*Izdeliye* 57T
Codename				
US	AA-3	AA-3	AA-3A	AA-3A
NATO (ASCC)	*Anab*	*Anab*	*Anab*	*Anab*
Service entry	1961	1961	1967	1972
Calibre	275 mm (10 53/64 in)	275 mm (10 53/64 in)	275 mm (10 53/64 in)	275 mm (10 53/64 in)
Length overall	4.18 m (13 ft 8 37/64 in)	4.0 m (13 ft 1 31/64 in)	4.26 m (13 ft 11 45/64 in)	4.14 m (13 ft 7 in)
Wing span	1.22 m (4 ft 0 in)	1.22 m (4 ft 0 in)	1.22 m (4 ft 0 in)	1.22 m (4 ft 0 in)
Launch weight, kg (lb)	275 (606.25)	227 (500.4)	275 (606 25)	227 (500.4)
Warhead weight, kg (lb)	40 (88)	40 (88)	40 (88)	40 (88)
'Kill' range, km (miles)	2-12 (1.24-7.45)	2-12 (1.24-7.45)	2-24 (1.24-14.9)	2-16 (1.24-9.9)
'Kill' altitude, m (ft)	5,000-23,000 (16,400-75,460)	5,000-23,000 (16,400-75,460)	5,000-23,000 (16,400-75,460)	500-24,000 (1,640-78,740)
Launch rail type	PU-1-8	PU 1-8	PU-2-8	PU-2-8
Missile platform	Su-11, Su-15, Yak-28P	Su-11, Su-15, Yak 28P	Su-15, Su-15T	Su 15 (modified), Su-15TM

Above: '232 Blue', the second prototype of the variable-geometry MiG-23 (*izdeliye* 23-11 2), with four dummy R-23 missiles. Note how the fins of the inboard missiles fit into special slots in the fuselage.

completed its test cycle and entered service with the PVO, as the starting point for the R-23's development. Hence the R-23 has the same layout with aft mounted rudders

In keeping with the established trend the R-23 was developed in two versions. The IR-homing R-23T (*izdeliye* 360) is designed for crossing engagements and attacks in pursuit mode around the clock in clear weather conditions (it is no good in clouds); targets flying both above and below the interceptor can be attacked. The semi-active radar-homing R-23R (*izdeliye* 340) is a far more potent weapon, giving true all-aspect engagement capability in any weather, as well as 'look-down/shoot-down' capability It is exhibits high resistance to ground clutter and enemy ECM

The R-23 has a modular design, the missile's body being divided into no fewer than eight sections Section 1 houses the seeker head, the IR seeker head of the R-23T has a liquid nitrogen cooling system enhancing its sensitivity considerably, which not only increases target lock-on range but also gives limited all-aspect engagement capability. Section 1 carries fixed trapezoidal canards (destabilisers) located in the same plane as the cruciform wings and rudders their span and area differ on the two versions of the missile – the R 23R, which is longer has larger destabilisers



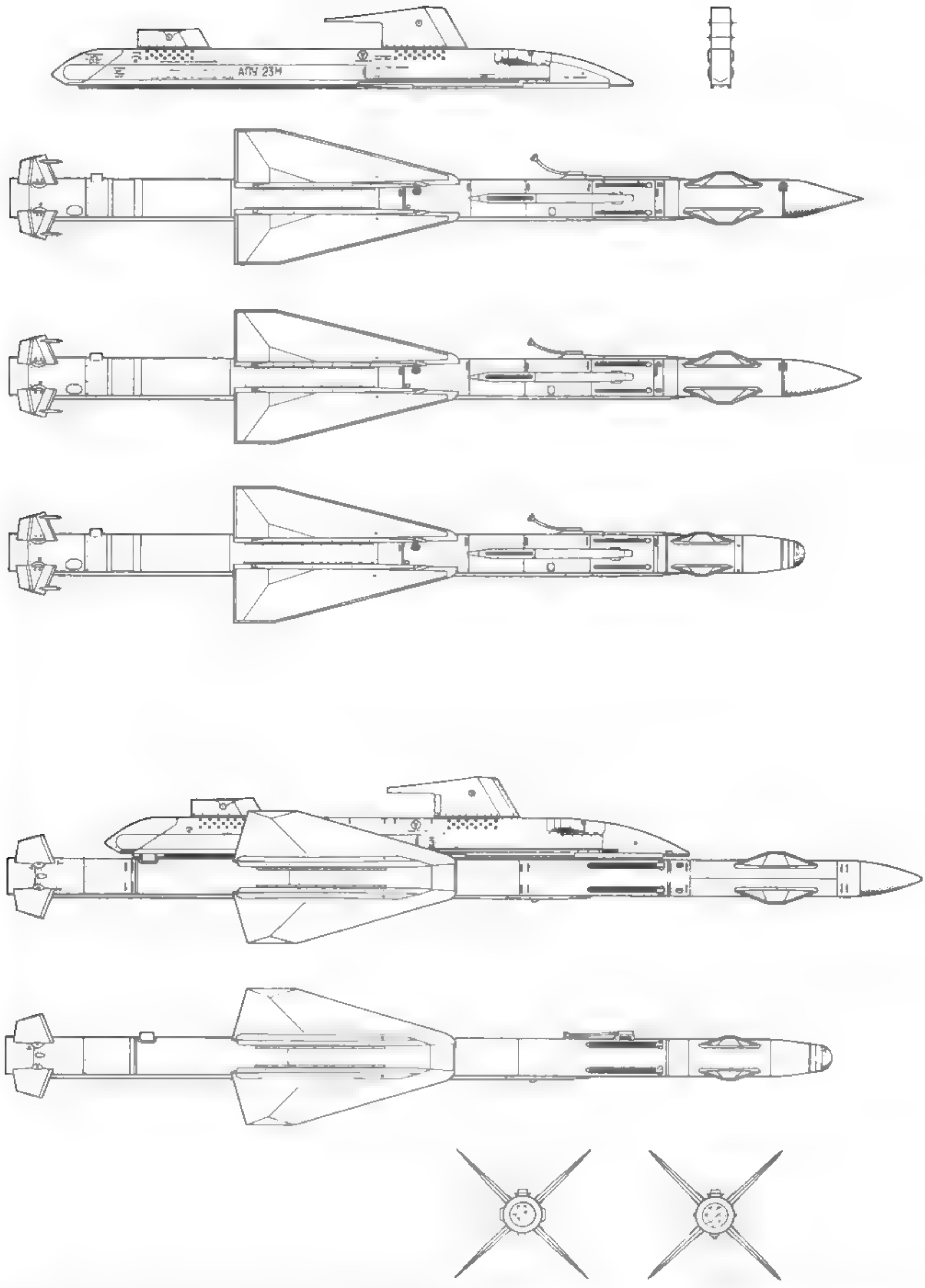
Section 2 houses the radar proximity fuse Its twin transmitter aerials are located in the horizontal plane, running all the way aft to Section 4, while the four receiver aerials are mounted on Section 2 in the planes of the wings Section 3 accommodates the autopilot and carries the forward mounting lug. Section 4 accommodates the warhead, which can be of either the HE/fragmentation or the continuous rod type

Section 5 is a power pack. It houses a powder gas pressure accumulator building up the working pressure for the rudder actuators and a turbine-driven generator – again actuated by rocket motor bleed gases

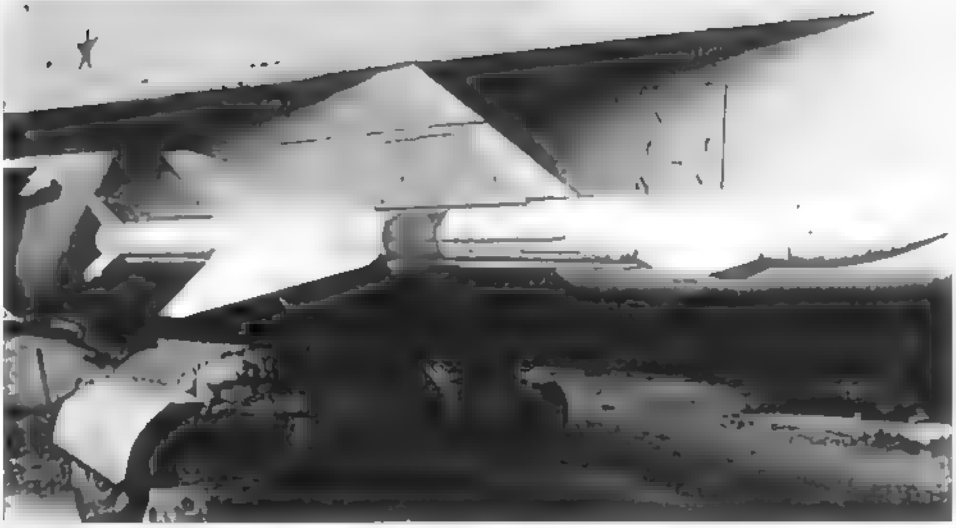
Section 6 is a solid-fuel rocket motor whose body carries the centre and rear mounting lugs It also carries the trapezoidal wings with a rhomboid airfoil. The wings have no ailerons, all control being exercised by means of differentially controllable rudders mounted further aft on Section 7 These are of trapezoidal planform with raked tips; protruding anti-flutter weights are installed on the leading edges near the tips. Section 7 is an annular structure fitting around the rocket motor nozzle The missile's body terminates in a tail fairing (Section 8) which may carry a ring-shaped tracer

The R-23 AAM was regarded as part of the S-23 armament system fitted to MiG-23s

Left A radar-homing R-23R on display at a museum. The lower fins have been removed.



Top to bottom. The APU-23M launch rail as fitted to the MiG-23M MF; the R-23R with two different versions of the radome; the R-23T; the R-24R missile on an APU-23M1 launch rail, the R-24T; and front views of the R-23T (left) and the R-24T



Left: A radar-homing R-23R with the ogival version of the radome on the an APU-23-11 launch rail fitted to the starboard wing glove pylon of a MiG-23 *sans suffixe*.

Below left: An IR-homing R-23T on the port wing glove pylon of the same aircraft. A mix of radar-homing and IR-homing missiles was usually carried to maximise the 'kill' probability

featuring a *Sapfeer 23* (Sapphire-23) fire control radar. However, the debugging of this radar was taking longer than anticipated, and the first production *Floggers* to enter service with the Soviet Air Force were MiG 23S fighters equipped with the more basic S-21 armament system; the latter was borrowed wholesale from the MiG-21SM and did not provide for the carriage of R-23 missiles. The intended armament system was only introduced in 1970 on a version known in pilot slang as ***dvadtsat' tretiy* 'bez *bookvy*'** – 'MiG-23 with no [suffix] letter', or *sans suffixe* ('1971-model MiG 23', this limited edition' was an intermediate version between the original MiG-23S *Flogger-A* and the MiG-23M *Flogger-B*

On the MiG-23 *sans suffixe* the R-23 missiles were carried on APU-23-11 launch rails From the MiG-23M onwards these gave place to APU 23M launch rails

R-24 air-to-air missile (R-24R/*izdeliye* 140; R-24T/*izdeliye* 160)

The R-24 is a version of the R-23 optimised for the penultimate variety of the *Flogger*, the MiG-23ML. Thanks to weight-saving measures the MiG-23ML (***lyohkiy*** – lightweight) had better manoeuvrability than the predecessors, while the new Sapfeer-23ML offered longer target acquisition range. Al this required the missiles' performance to be improved in order to match the fighter's greater potential

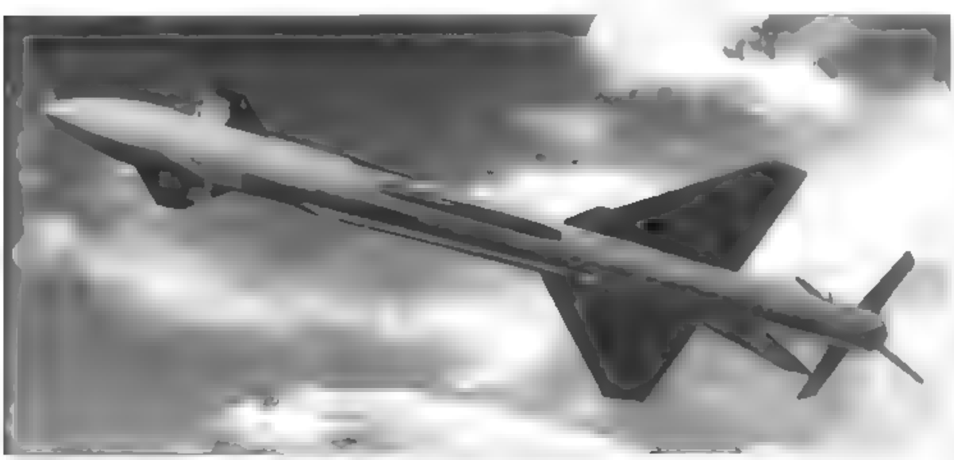
To this end the R-23 was fitted with an improved radar proximity fuse and more refined SARH and IR seeker heads, these changes increased the missile's length by 0.34 m (1 ft 1$\frac{25}{64}$ in), causing a forward shift in the CG position. Hence, in order to restore the CG position and improve the missile's stability the warhead was moved aft to a position between the rocket motor and the rudders. The wing attachment points on the body were also moved aft and the wing planform was altered, with forward sweep on the trailing edges New airfoils were used for the wings and rudders, which allowed the rudders' anti-flutter weights to be dispensed with. The missile's weight rose by 25-30 kg (55-66 lb)

Designated R-24, the redesigned missile joined the inventory in 1981 in two versions – the semi active radar-homing R-24R (*izdeliye* 140) and the IR-homing R-24T (*izdeliye* 160). In addition to the MiG-23ML the missiles were carried by two further versions – the MiG-23P and the MiG-23MLD. Modified APU-23M1 launch rails were used with the R-24

R-27 (K-27, *izdeliye* 470) air-to-air missile

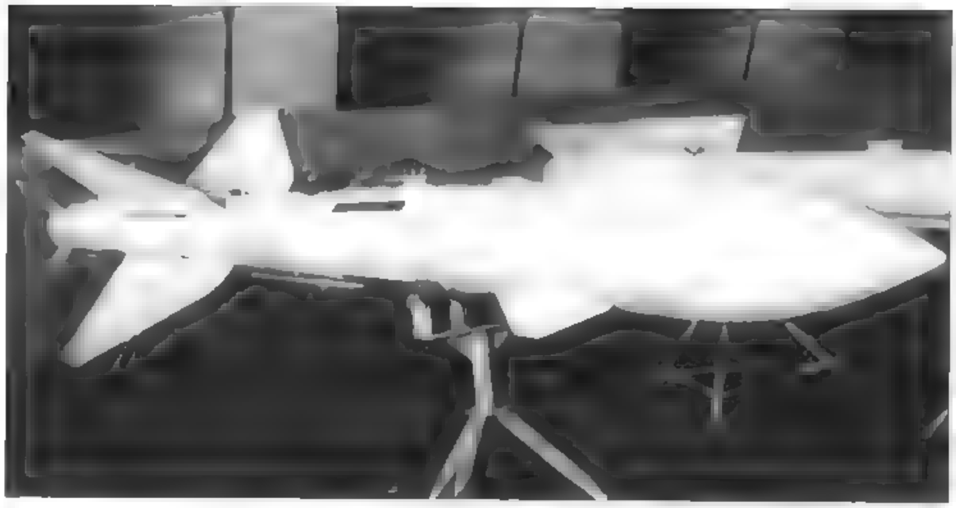
The R-27 (*izdeliye* 470) AAM is designed for destroying aerial targets both at long range and in a dogfight – also during concerted actions by a group of fighters. The missile has all-aspect engagement capability and offers 'look-down/shoot-down' capability over land and water, regardless of the enemy's evasive actions and ECM

The R-27 is a further evolution of the R-24, it was developed for the new fourth-generation air superiority fighters – the MiG-29 and Su-27. The missile's design benefited from the know-how accumulated while developing the R-60 short-range AAM



Left An artist's impression of the R-24R missile, showing the larger-span wings and rudders (which is not true) and the longer body.

Right: An R-24R on display at an airshow at Kubinka AB The altered wing planform and the longer body as compared to the R-23R are clearly visible, as are the smaller destabilisers.



Below right: This view gives an interesting comparison of the R-24R and its successor, the R-27R.

The R-27 is the first Soviet AAM to feature a modular design that permits development of a whole family of missiles differing not only in guidance system type but also in the size of the body modules while using identical fins and rudders for all versions. The resulting versions have different performance and are suited for different launch conditions

One of the features of the R-60 incorporated into the new missile is that the R-27 has a canard layout with additional fixed canards (destabilisers) ahead of the rudders. The body is made up of five sections. Only Section 4 (the warhead, which can be of the high-explosive/fragmentation or continuous rod type) remains constant, the others can be replaced to suit specific requirements, with attendant changes in the missile's designation

All versions can be equipped with either an all-aspect IR seeker head or a semi-active radar seeker head, accordingly the suffix letter T (= IR-homing) or R (= SARH) is added to the designation. The foremost section housing the seeker head also carries the destabilisers

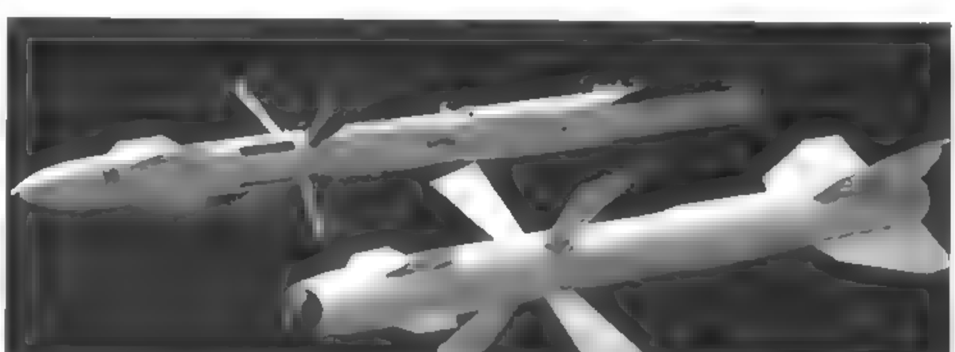
On the Su-27 and MiG-29 the R 27T is carried solely on APU-27 (alias APU-470) launch rails incorporating liquid nitrogen bottles for cooling the IR seeker head while the missile is on the wing, and then only on the innermost wing hardpoints. The R-27R is carried by the Su-27 on AKU-27 (AKU-470) ejector racks fitted under the air intake trunks (one each) and on the fuselage centreline (two in tandem). Immediately before launch the R-27R is lowered into pre-launch position by the rack's pantographic mechanism, the rocket motor fires after the missile falls clear of the aircraft

Module 2 houses the radar proximity fuse and the autopilot, which are identical on all versions of the R-27. It carries four transmitter/receiver aerials for the proximity fuse

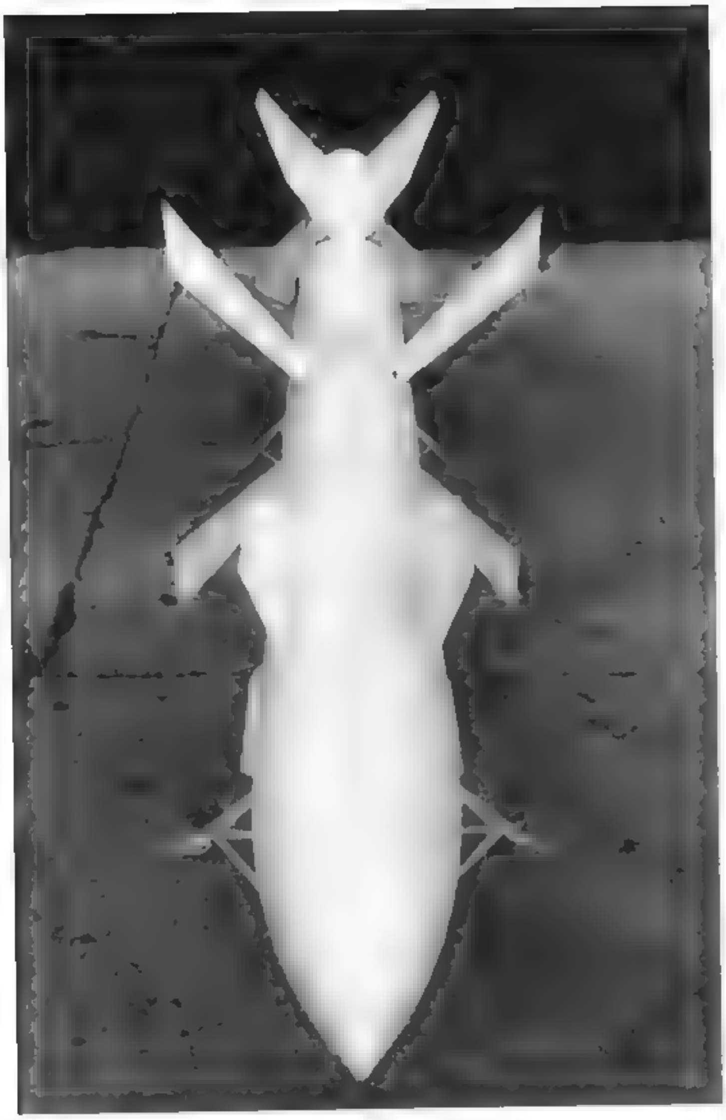
Module 3 mounts the rudders and accommodates their electrohydraulic actuators, as well as the electric power sources The cruciform rudders have a relatively large area and an unconventional reverse-tapered planform (which is why they are sometimes called 'butterfly-type rudders'); their span (0 97 m/3 ft 2 3/16 in) exceeds the span of the fins (0 77 m/2 ft 6 5/16 in). These features have made it possible to avoid reverse roll reaction to differential rudder inputs in all flight modes and obviated the need for ailerons or rollerons

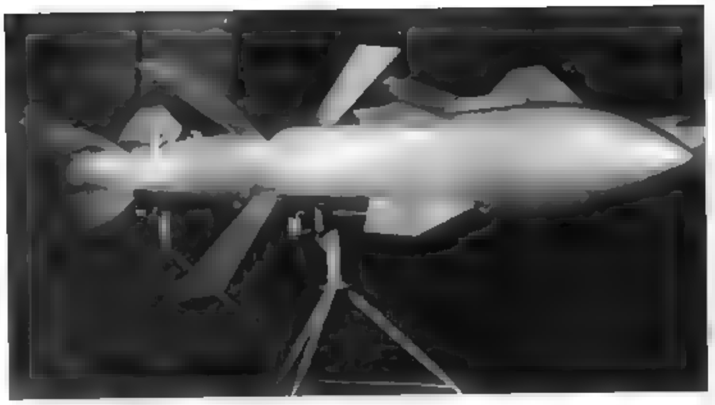
As noted earlier, Module 4 is an HE/fragmentation or continuous rod warhead Module 5 is a solid fuel rocket motor, it is available in two versions differing in length and diameter. The two differently sized motors give the missile different thrust/weight ratios and different 'kill' ranges. Missiles equipped with the bigger motor have an E suffix added to the designation (that is R-27ET and R-27ER), as in the case of the R-73E, the E stands for ***energovo'oroozhonnaya*** ('high-powered') The R-27ET and R-27ER are 0.7 m (2 ft 3½ in) longer and have a 0 03 m (1 3/16 in) greater maximum body diameter, nevertheless, the calibre of the R 27T/R and the R-27ET/ER is considered to be identical (230 mm/9 in), being determined by the diameter of the warhead module

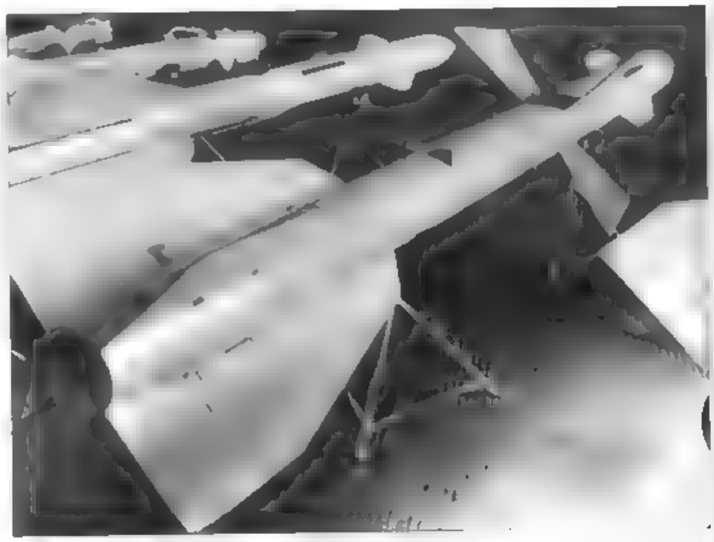
The cruciform fins, which are identical for all versions, are attached to the body of Module 5. The distance between them and the wings is 0 7 m greater on the 'high-powered' versions due to the larger dimensions of the propulsion module, which makes sure that the missile's control characteristics



Right: The R-27ET (foreground) and R-27ER. Both versions feature a longer-burn rocket motor of increased diameter.





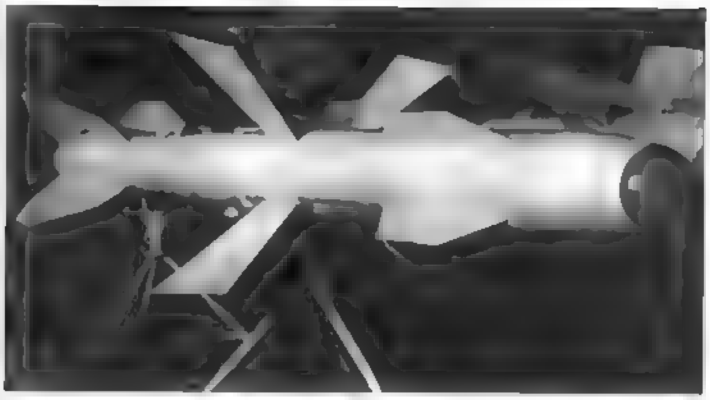


Top and left: These views of the R-27R show the constant body diameter of the standard (that is, 'short-burn') version and the trapezoidal destabilisers.

Above: Another aspect of the R-27R, illustrating the reverse-tapered rudders with raked tips and the double-kinked leading edges of the fins.

The following table gives comparative specifications of the R-23 and R-27.

	[redacted]	R-23T	R-27R	R-27T
Product code	*Izdeliye* 340	*Izdeliye* 360	*Izdeliye* 470	*Izdeliye* 470
Codename				
US	AA-7A	AA 7B	AA 3A	AA 3B
NATO (ASCC)	*Apex*	*Apex*	*Alamo-A*	*Alamo-B*
Service entry	1970	1970	1983	1983
Calibre	200 mm (7⅞ in)	200 mm (7 in)	230 mm (9 in)	230 mm (9 in)
Length overall	4 46 m (14 ft 7 19/32 in)	4 16 m (13 ft 7 in	4 08 m (13 ft 4⅝ in)	3 795 m (12 ft 5 13/32 in)
Wing span	1 0 m (3 ft 3⅜ in)	1 0 m (3 ft 3 in	0 772 m (2 ft 6 in)	0 772 m (2 ft 6 25/64 in)
Launch weight, kg (lb)	223 (491)	216 (476)	253 (557)	245 (540)
Warhead weight kg (lb)	25 (55)	25 (55)	39 (86)	39 (86
'Kill' range km (miles)	2 5-27 (1 5-16 75)	3 15 (1 86 9 3)	0 2 80 (0 12 49 6)	0 2-30 (0 12-18 6)
'Kill' altitude, m (ft)	0-25.000 (0-82 020)	0-25 000 (0-82 020	n a	n a
Launch rail type	APU 23-11 APU-23M	APU 23-11 APU 23M	AKU-470	AKU-470
Missile platform	MiG 23 MiG-23M (MF)	MiG 23 MiG 23M (MF	Su-27 MiG-29 Yak 141	Su-27 MiG-29 Yak-141

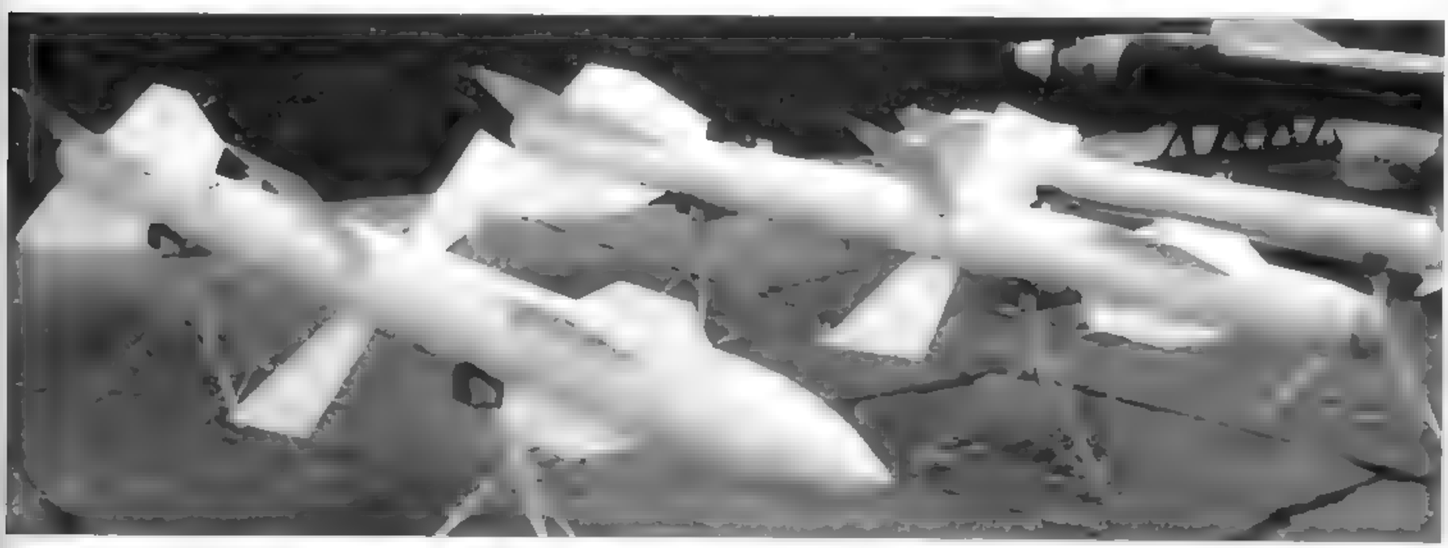


Top and above: The R-27R version differs only in having an infra-red seeker head and is therefore slightly shorter

Right: Another view of the R-27R, showing the hemispherical nose of the IR seeker head.

remain unchanged; the span of the fins is increased by 0 03 m for the same reason The R-27 has three mounting lugs which are identically positioned on all versions

In the case of the IR-homing versions the target is initially acquired by the fighter's radar, whereupon target information is downloaded to the missile's seeker head the latter can lock on to the target at a maximum range of 80 km (50 miles) Depending on the fighter's flight level, the missile launch range is 0.2-30 km (0 12-18 6 miles) For the radar homing versions the course of action is the same but maximum lock-on range is only 40 km (25 miles). Hence it is possible to fire the R-27R (R-27ER) before target lock-on is achieved, in this case the missile receives mid-course guidance via a special command link system to compensate for the target s movement until it comes within lock-on range. The mid-course correction feature increases the effective 'kill' range by some 20 km (12.4 miles) in pursuit mode and 60 km (37 miles) in head-on mode. Two mis-



The two baseline versions of the R-27 (the R-27R, left, and the R-27T) displayed together at an airshow.

Left: A still from a video showing a MiG-29 firing an R-27 from the port inboard wing pylon. The baseline MiG-29 *Fulcrum-A/C* can carry two R-27s on the inner wing hardpoints only; the 'second-generation' MiG-29M can carry two more.

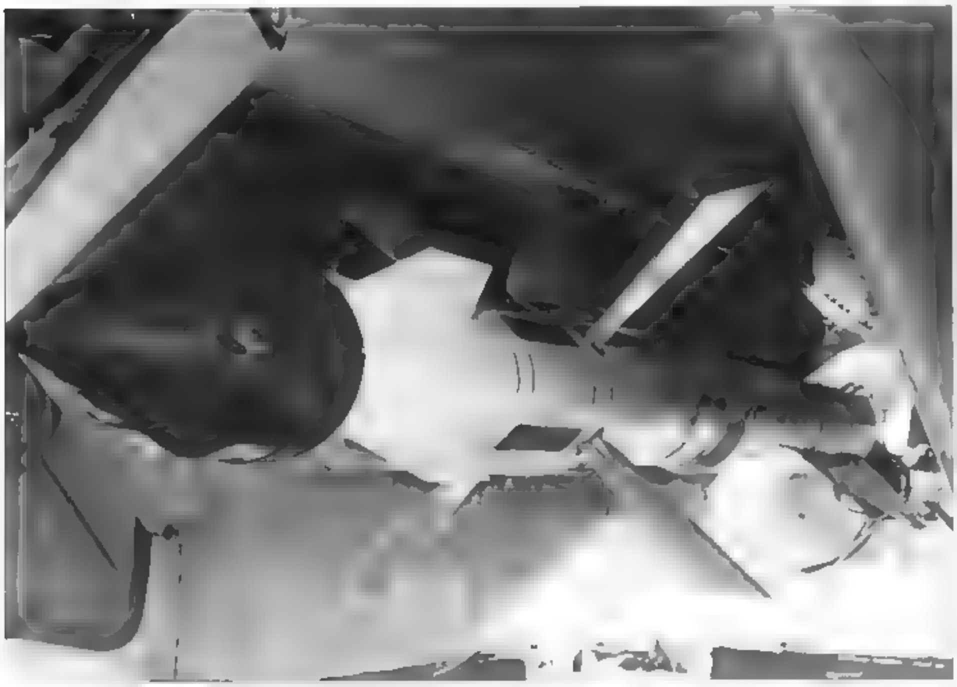
siles can be guided to two targets simultaneously

In addition to the well-known R-27T/ET and R-27R/ER, a special 'navalised' version designated R-27EM was developed for the Su-27K, MiG-29K and Yak-141 shipboard fighters (of which only the former has seen production and service with the Russian Navy as the Su-33). This is a radar-homing missile but, unlike the R-27ER, it lacks the mid-course guidance system, being designed for use primarily against low-flying targets over water. Instead, the R-27EM features an upgraded seeker head enabling it to take out targets flying as low as 3 m (10 ft). The proximity fuse is modified accordingly and its aerials are repositioned.

Another advanced version, the R-27AE, is a 'wish 'em dead' weapon - provided you have target lock-on. Unlike the R-27ER from which it is derived, the R-27AE has active radar homing (hence the A suffix), this obviates the need for continuous target illumination by the fighter's radar after launch, once it is locked on. This makes it the first Russian missile to utilise the 'fire and forget' principle characterising the latest generation of air-to-air missiles. Outwardly the R-27AE can be discerned from the R-27ER by the conical shape of the radome instead of the usual ogival one, a feature which has reduced overall length by 45 mm (1¾ in)

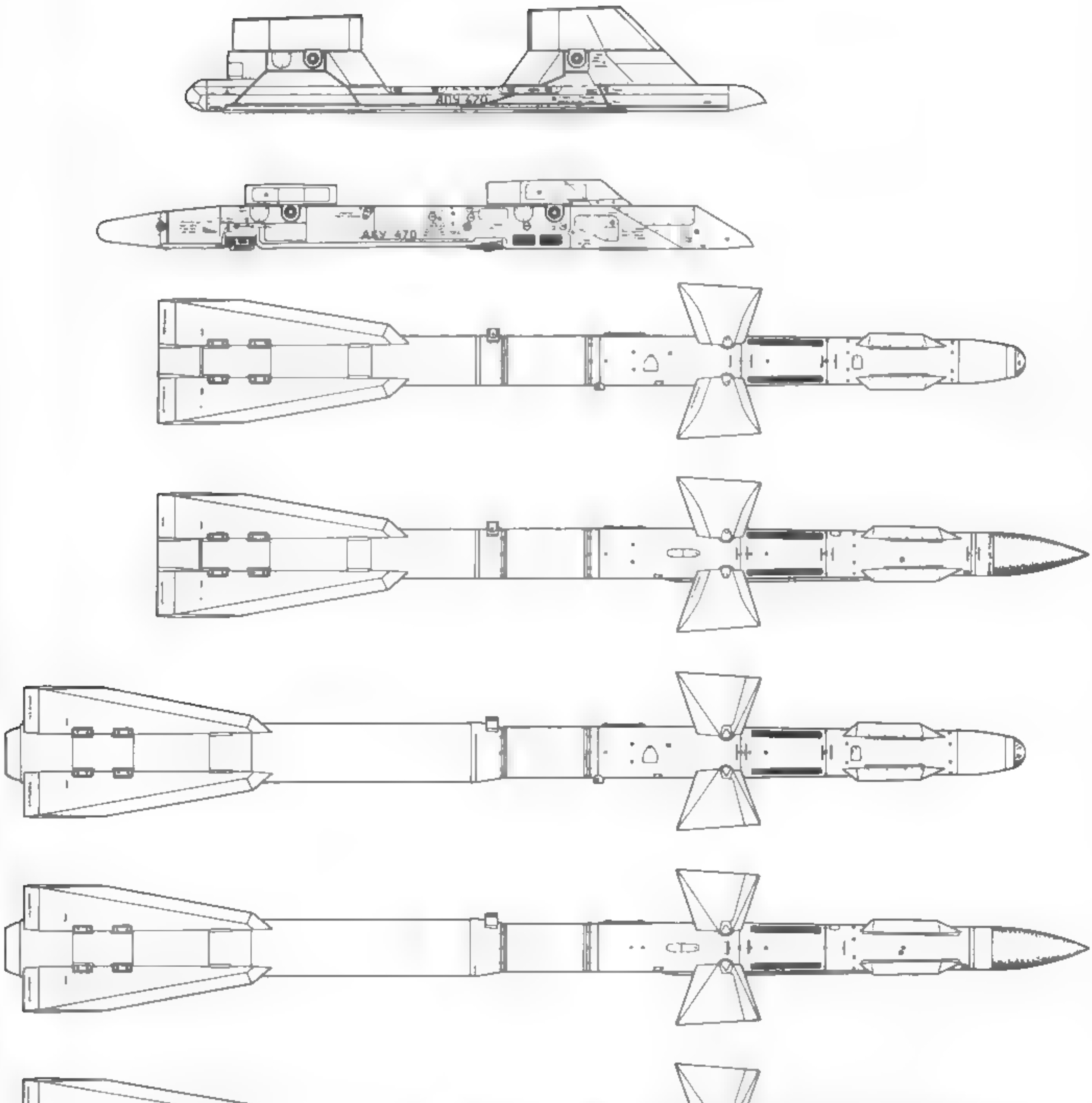
R-4 (K-80) air-to-air missile

In the mid-1950s OKB-156 led by Andrey N. Tupolev began development of the Tu-28 supersonic heavy interceptor. Redesignated Tu-128 after entering production and service, it was then the world's only aircraft in its class, and to this day it remains the biggest-ever interceptor. Hence the Bisnovat OKB was tasked with developing the Soviet Union's first all-aspect AAM for this aircraft, designated K-80, it was designed for destroying strategic bombers, reconnaissance aircraft, cruise missile strike aircraft and such. In keeping with the already established trend the K-80 was developed in two versions at once – SARH and IR-homing. The former had all-aspect engagement capability, while the heat-seeking version could be used for attacks at aspects up to three-quarters rear view



Above left: An inert R-27ER with a protective cap over the radome on the forward centreline pylon of a Su-27.

Left. Another inert R-27ER, this time with black stripes; under the starboard engine nacelle of a Su-27. The Su-27 can carry six R-27s.



Top to bottom The APU-470 missile rail, the AKU-470 ejector rack; the R-27T; the R-27R, the R-27ET; the R-27ER; the R-27AE, the R-27EM

Left: A pre-production MiG-29 *Fulcrum-A* (note the nose gear door segment mounted on the oleo strut) carrying two dummy R-27Rs, four dummy R-60Ms and a centreline drop tank.

Below left: '311 Blue', the first prototype of the shipboard MiG-29K (note arrester hook), armed with a pair of 'navalised' R-27EMs and a pair of [illegible].

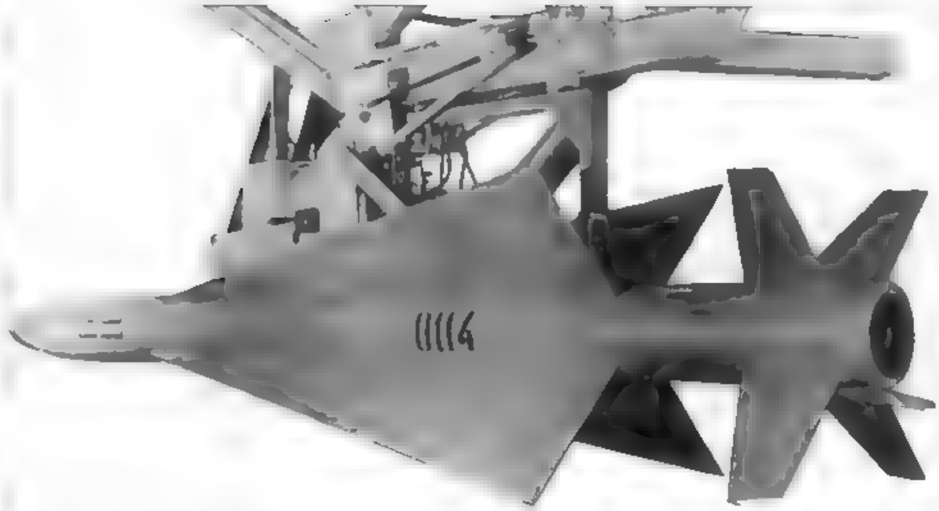
Bottom left: The upgraded MiG-29SMT prototype ('917 Blue') with an impressive arsenal arrayed in front of it. Two inert R-27Ts and a GSh-301 cannon are foremost, with R-73s and the centreline drop tank in the second row, followed by Kh-25ML and Kh-31P air-to-surface missiles, guided bombs and underwing drop tanks.

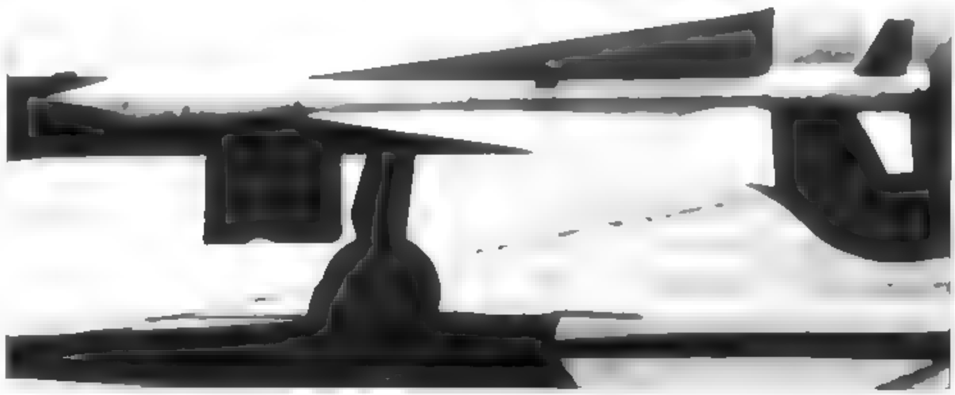
This page, top: A prototype K-80 missile on a ground test launcher

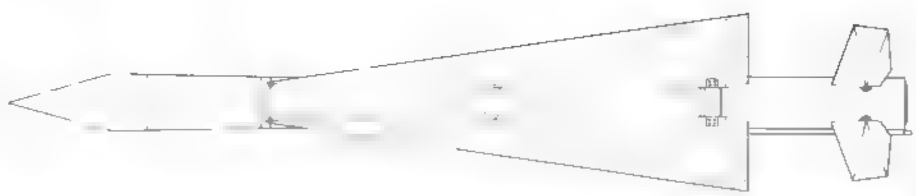
Centre right: A K-80 on the wingtip launch rail of the Mikoyan Ye-152P interceptor prototype.

Above right: A drawing of the K-80.

Right: Assembly of K-80 missiles at the plant



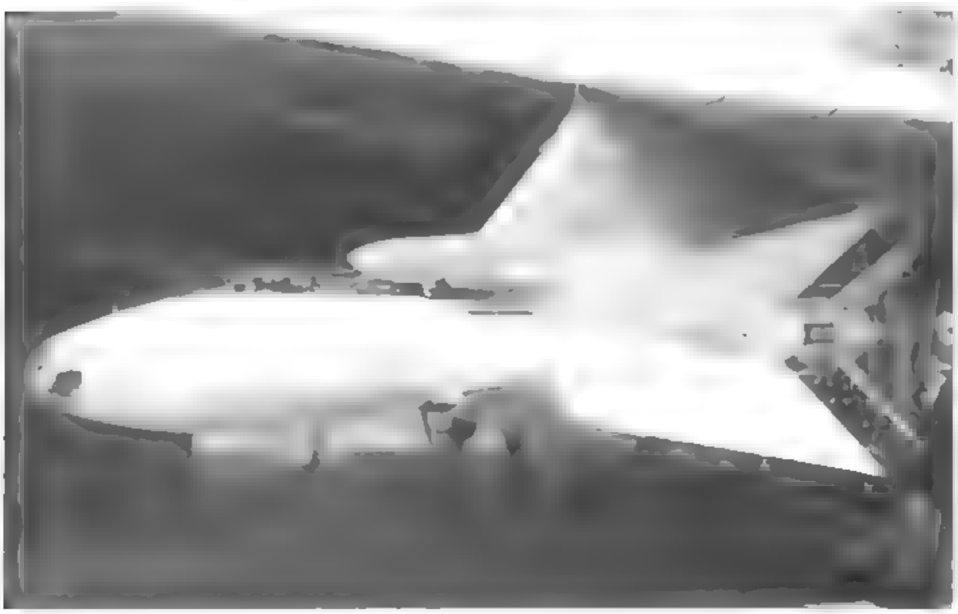




A curious feature of the all-aspect SARH version was the wide variance in its parameters stipulated by the operational requirement. For example, depending on the launch conditions the missile's speed could be anywhere between 200 and 1,600 m/sec (720-5,760 km/h, or 447-3,577 mph). With such a variance in closing speeds it was impossible to provide high homing accuracy and hence a high 'kill' probability unless the parameters of the missile's control system and proximity fuse were coordinated with the missile's closing speed Since the missile's onboard systems might find it difficult to establish the latter, especially in an ECM environment, the necessary information would be downloaded from the interceptor to the missile at the moment of launch

The designers succeeded in enhancing the K-80's manoeuvrability considerably as compared to existing Soviet AAMs A lateral G force limit of 21 was attained thanks to the dramatically reduced wing loading – up to 130 kg/m² (26 65 lb/sq ft) during the passive (coasting) stage of the flight – and a high thrust/weight ratio (the rocket motor made up 25% of the launch weight). In order to use the missile s G limits to the full the roll control circuit was designed to match the plane permitting maximum manoeuvrability with the plane where the radar signal was the strongest. The K-80's guidance system utilised the proportional navigation method

The K-80 missile entered production in 1963 under the service designation R-4; two years later it was formally included into the PVO inventory as part of the Tu-128S-4 aerial intercept weapons system. In order to increase the missile's ECM resistance and maximise 'kill' probability the R-4 was



Left. An inert R-4T heat-seeking missile on a ground handling dolly. The slightly bulged nose section carries the stencil *oochebnaya* (training)

Below left. Another view of the same missile, showing the shape of the wings and rudders (the rudder tips are raked to improve flutter resistance), the proximity fuse aerials aft of the wings and the tracers flanking the rear end.

Bottom left: The same missile on the pylon of a Tu-128 interceptor

manufactured in three versions: the R-4R (*izdeliye* 36R) with a semi-active radar seeker head and a radar proximity fuse, the R-4T (*izdeliye* 36T) with an IR seeker head and a radar proximity fuse, and the R-4TI (*izdeliye* 36TI) with an IR seeker head and an optoelectronic proximity fuse. Originally known as the R-4RR, R-4TR and R-4TI respectively, they differed outwardly in the shape and size of the forward body section

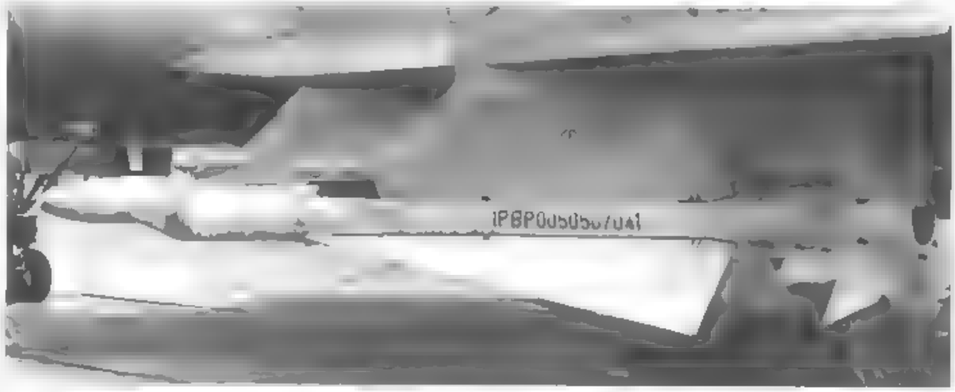
The need to maximise agility by reducing the wing loading and providing a high thrust/weight ratio led the designers to choose a conventional layout with aft-mounted rudders The missile has cruciform wings and rudders set at 45° to the horizontal plane. The airframe is designed to permit components interchangeability between all versions; to this end the systems and equipment are divided into modules and the airframe is manufactured in four sections

Section 1 housing the seeker head is a conical dielectric radome on the R-4R or a parabolic metal fairing with an aperture on the R-4T/R-4TI. Section 2 accommodates the fuse, the high explosive/fragmentation warhead, the automatic electric control equipment and the autopilot. In the case of the R-4R the radar proximity fuse's rectangular transmitter/receiver aerials are located at the front of the section, on the R-4T the receiver aerials are relocated to Section 4 The R-4TI differs in having a longer Section 2 which incorporates two 'viewing ports' on each side for the optical proximity fuse

Section 3 is a solid-fuel rocket motor with a maximum impulse of 24,500 kgp (54,000 lbst) at sea level, the burn time is 4.5-7 seconds The motor housing incorporates wing attachment fittings and mounting lugs for hooking the missile up to the launch rail A conduit accommodating wiring bundles, pneumatic lines and a waveguide for the rear guidance aerial is located ventrally on Section 3

Section 4 incorporates the rocket motor nozzle, it houses air bottles for the rudders' pneumatic actuators and carries the rudders themselves, with a separate actuator for each rudder The aft end is flanked by two tracers, and the rear section of the above-mentioned waveguide runs along the underside The R-4T features two lateral receiver

Right and below right: The Tu-128 carried IR-homing R-4T missiles on the inboard pylons and semi-active radar-homing R-4Rs outboard.



aerials for the proximity fuse located on Section 4; in the other two versions the apertures for these are closed by plugs

The basic body diameter regarded as the missile's calibre is 315 mm (1 ft 0$^{13}/_{32}$ in) and is constant throughout, except for the foremost section and the front end of Section 2. The maximum body diameter is 340 mm (1 ft 1$^{25}/_{64}$ in) for the R-4R and 343 mm (1 ft 1½ in) for the R-4T/R-4TI

The large delta wings use a trapezoidal airfoil and are two-spar stressed-skin structures with a 'solid' trailing edge (without ailerons). The rudders have a trapezoidal planform with raked tips; they are single-spar stressed-skin structures with anti-flutter weights integrated into the leading edges. The rudders serve both for pitch/yaw control and for roll stabilisation. Stabilisation around the CG and differential rudder deflection are performed by the autopilot

Pre-launch operations and guidance are performed by the Tu-128's Smerch (Tornado) weapons control system comprising an RP-S fire control radar and a computer. If the R-4R SARH missile is used, the radar has to provide continuous target illumination from launch to detonation. To stop the interceptor from colliding with the target (or its debris), target illumination continues until the aircraft comes within minimum safe range of the target, whereupon the computer instructs the pilot to break off the attack. Continuous target illumination is not needed if the R-4T heat-seeking missile is used, it can be launched even if the Smerch WCS fails. If this is the case, the pilot uses an optical sight and the pre-launch operations are performed by the weapons systems operator in the rear cockpit

The capacity of the R-4's DC batteries and compressed air bottles is sufficient for supporting the operation of the missile's systems during 40 seconds of flight. During the active stage of the flight (in powered flight) the missile zeroes in on the target, a process which continues after burnout when the missile coasts. Forty seconds after launch the missile self destructs, unless the fuse detonates the warhead before that

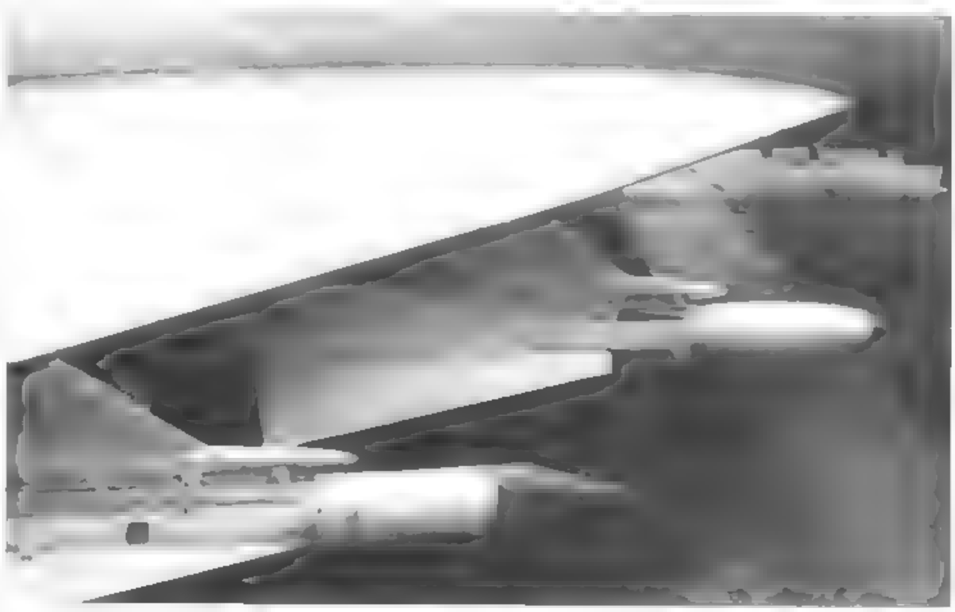
The R-4 can be used against targets flying at speeds up to 2,000 km/h (1,240 mph) and altitudes of 8,000-21,000 m (26,250-68,900 ft) – that is, up to 7,000 m (22,965 ft) above the interceptor's own flight level, the launch range is anywhere between 2 and 25 km (1.24-15.5 miles). The Tu-128 can carry four missiles on APU-128 launch rails, although the first prototype (designated Tu-28) initially had only two missile pylons. A mix of missiles is normally carried, with IR-homing R-4T's (or R-4TIs) on the inboard stations and radar-homing R-4Rs on the outboard ones. The R-4R missile also found use on the Mikoyan/Gurevich Ye-152M single-seat heavy interceptor prototype developed in the early 1960s, two such missiles were carried under the wings

R-4M air-to-air missile

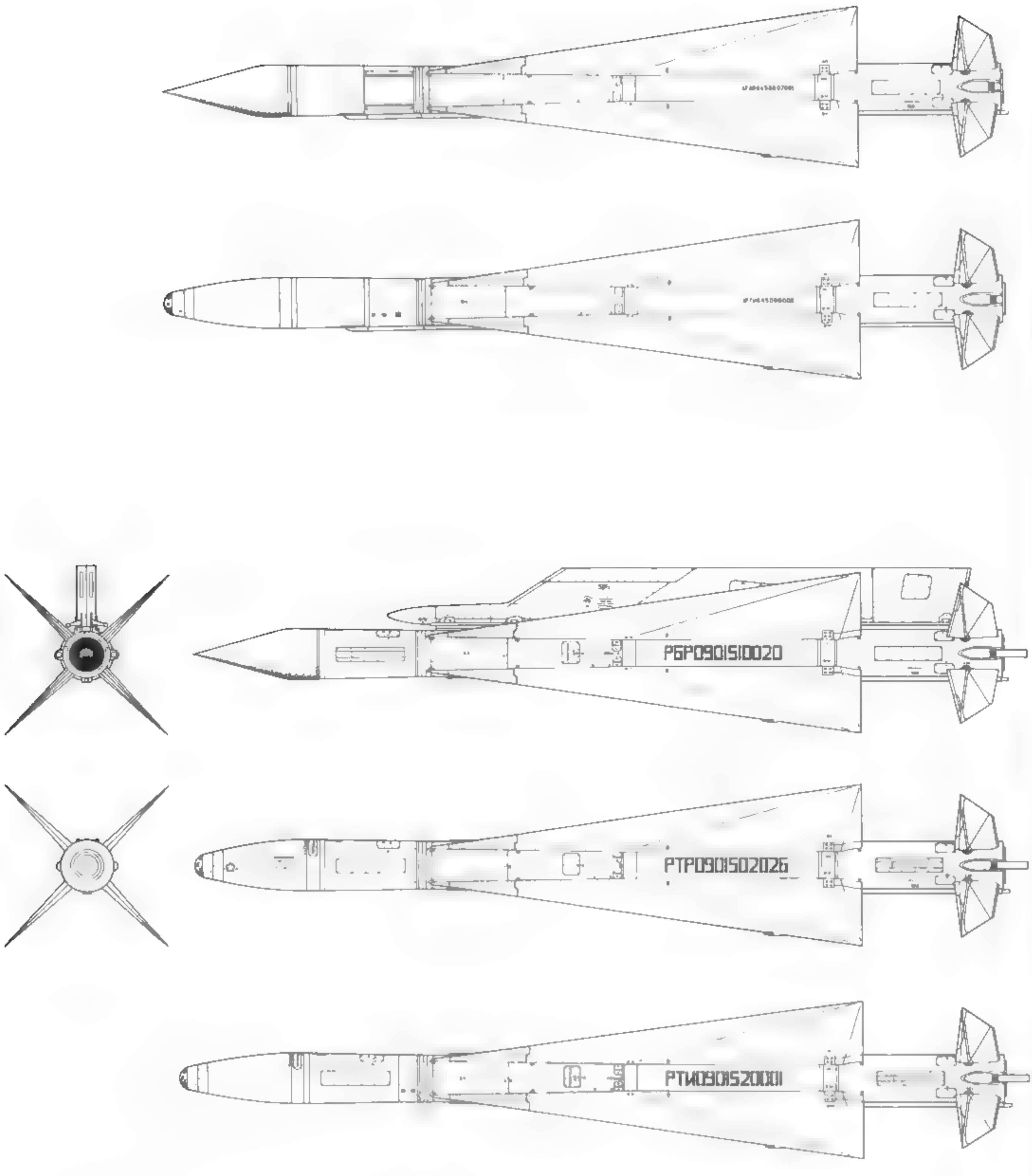
The R-4M missile was brought out in the late 1960s as a refined version of the R-4 intended for the upgraded Tu-128S-4M aerial intercept weapons system built around the Tu-128M interceptor featuring the RP-SM (Smerch-M) radar. Once again the upgraded missile was produced in two versions, the semi-active radar homing R-4RM (*izdeliye* 36RM) with a radar proximity fuse and the IR-homing R-4TM (*izdeliye* 36TM) with a combined radar/optical proximity fuse

As before, the SARH version is carried on the outboard pylons and the IR-homing version on the inboard ones. If necessary the Tu-128M can carry a mix of R-4Ms and 'old' R-4s, in these cases R-4Rs are carried outboard and R-4TMs inboard, alternatively, R-4TMs can be fitted to the outboard pylons, with R-4Ts or R-4TIs inboard

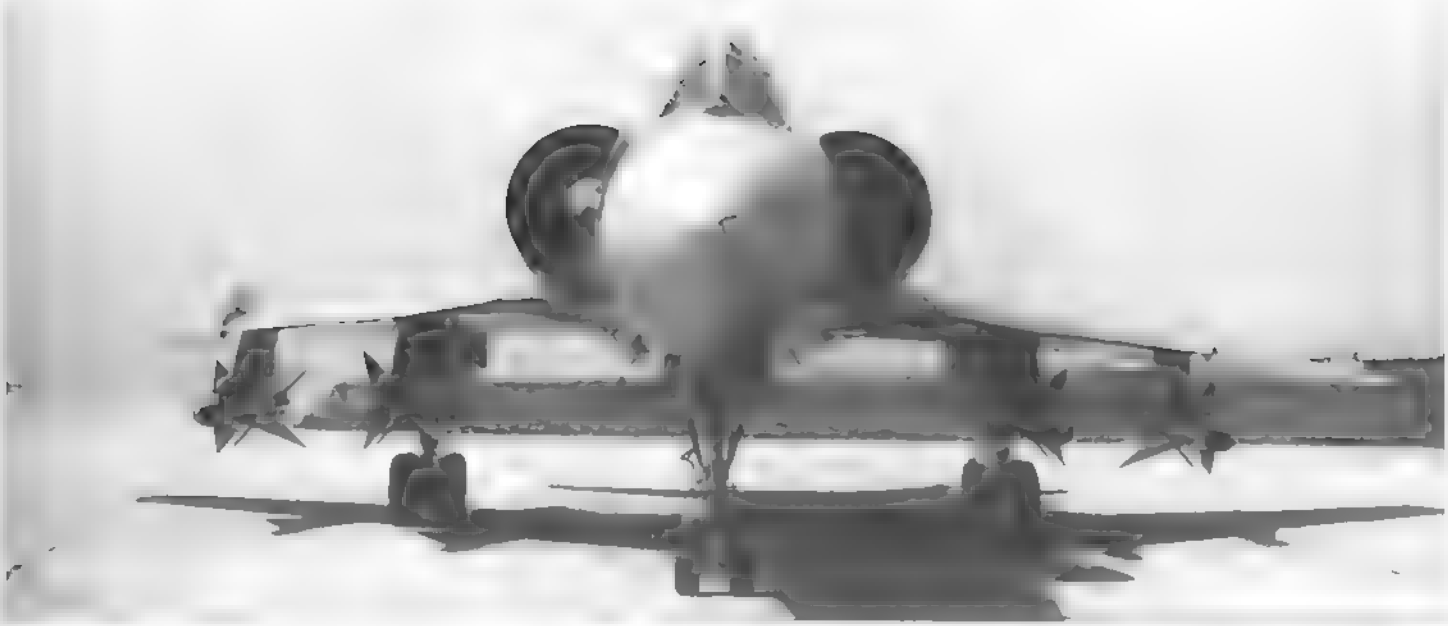
Outwardly the R-4M differs from the preceding variants only in being slightly longer however, both versions feature new seeker



Another view of the starboard APU-128 missile rails of a Tu-128, showing the special strut-mounted sway braces



Top to bottom: The R-4RM; the R-4TM, the R-4RR; the R-4TR; and the R-4TI The front and rear views pertain to the R-4TR.



Above: The fourth production Tu-128 interceptor (c/n 1400202) seen during trials with four red-painted dummy R-4 missiles on the pylons.

Right: A production Tu-128 takes off, carrying only a pair of R-4T missiles on the inboard pylons.

Below: A typical operational Tu-128M standing on quick-reaction alert, with a full complement of missiles and a ground power cable connected for engine starting at a moment's notice. The radomes of the R-4RMs and the seeker heads of the R-4TMs are protected against the elements by metal covers

	[illegible]	R-4T (R-4TI)	R-4RM	R-4TM
Product code	*Izdeliye* 36R	*Izdeliye* 36T (izdeliye 36TI)	*Izdeliye* 36RM	*Izdeliye* 36TM
Codename				
US	AA 5	AA-5	AA-5A	AA-5A
NATO (ASCC)	*Ash*	*Ash*	*Ash*	*Ash*
Service entry	1965	1965	1975	1975
Calibre	315 mm (1 ft 0 13/32 in)	315 mm (1 ft 0 13/32 in)	315 mm (1 ft 0 13/32 in)	315 mm (1 ft 0 13/32 in)
Length overall	5.36 m (17 ft 7 in)	5.36 m/5.48 m* (17 ft 11¾ in*)	5.55 m (18 ft 2½ in)	5.57 m (18 ft 3 9/32 in)
Wing span	1.5 m (4 ft 11 in)	1 5 m (4 ft 11 in)	1.5 m (4 ft 11 in)	1 5 m (4 ft 11 in)
Launch weight kg (lb)	492 (1,084)	494, 497* (1 089, 1 095*)	500 (1,102)	492 (1 084)
Warhead weight kg (lb)	53 (116 8)	53 (116.8)	53 (116.8)	53 (116.8)
Kill range, km (miles)	2-30 (1.24-18 6)	2-30 (1.24-18.6)	2-30 (1.24-18 6)	2-30 (1.24-18.6)
Kill altitude, m (ft)	8,000-21,000 (26,250-68,900)	8,000-21,000 (26,250-68,900)	8,000-21,000 (26 250-68 900)	8,000-21 000 (26,250-68,900)
Speed, m/sec (km/h, mph)	1,000 (3 600 2,236)	1 000 (3 600 2,236)	1 000 (3,600; 2 236)	1 000 (3,600; 2 236)
Missile platform	Tu-28, Tu-128 Tu-128M Ye-152M	Tu-128 Tu-128M	Tu-128M	Tu-128M

Note: The figures marked with * apply to the R-4TI

heads. The R-4RM's semi-active seeker head gives all aspect engagement capability even in ground clutter or an ECM environment. The ventral conduit is extended forward all the way to Section 1

Section 2 is divided into two separate subassemblies, allowing the fuse to be replaced The forward bay houses a new radar or radar/optical fuse allowing the missile to approach the target from any angle The radar fuse has two transmitter aerials and two receiver aerials located in the same planes as the wings The R-4TM's radar/optical version boasts better ECM resistance having two independent channels (radar and optical) working in parallel, appropriate sighting windows are provided. The decision to use a combined fuse was prompted by the positive experience with a similar design on the R-40 AAM carried by the MiG-25 interceptor (see below)

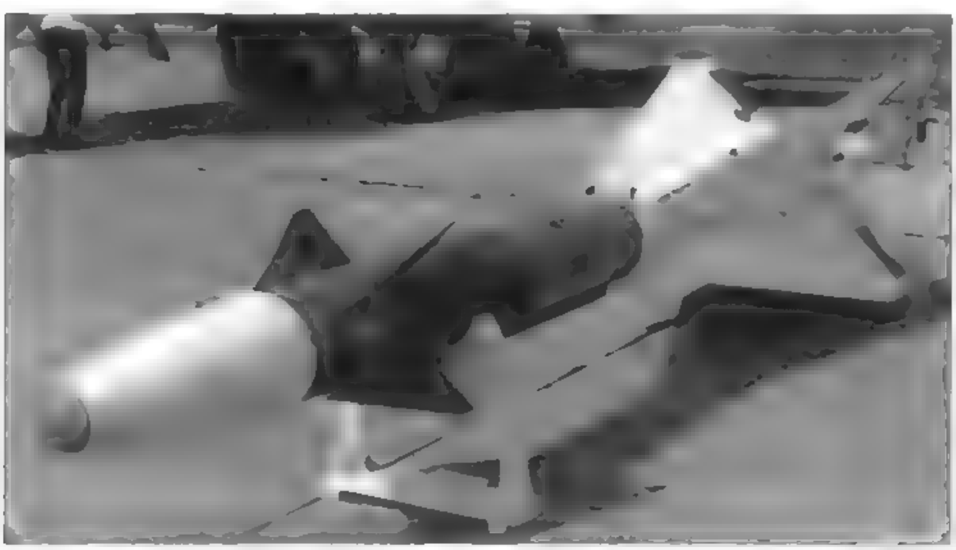
The R-4M features rudders of reduced area; the reduction is due to a shorter root chord and reduced leading-edge sweep The performance of the upgraded version differs little from that of the original R-4, as can be seen in the table above

R-40 (K-40, *izdeliye* 46) air-to-air missile

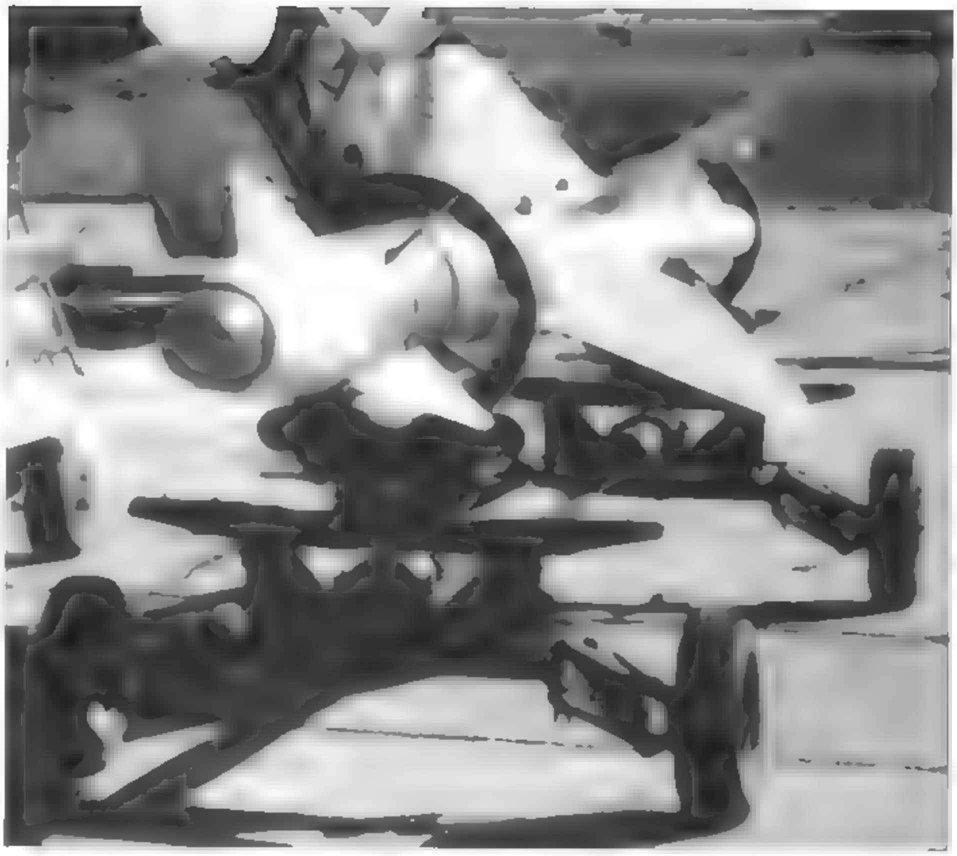
In the early 1960s the Bisnovat OKB was tasked with developing guided missiles for the Mikoyan OKB's latest product, the Ye-155P interceptor capable of Mach 3 flight (this aircraft entered production and service as the MiG-25P). The new missile was required to destroy high-speed targets flying high and low at any time of day and regardless of enemy countermeasures. In a nutshell, this was to be the first indigenous hypersonic weapon

Preliminary research and development work showed that the designers would have to revert to the canard layout with the new missile, which received the designation R-40. With a centrally placed solid-fuel rocket motor, the centre of gravity position would not be affected significantly by fuel burnoff; also, the canard layout ensured that the missile would be able to sustain the required G loads and so on

The R-40 features a modular design making large-scale co-operation between different plants possible during the missile's manufacture and allowing various components to be replaced in service in case of need The body is built in five sections, the first of which houses the seeker head As usual, two types of the latter are available the SARH version of the missile is called R-40R (*izdeliye* 46R) and the IR-homing version is designated R-40T (*izdeliye* 46T) Both seeker heads are characterised by a long



Left: An R-40TD on display at one of the Moscow airshows Note the red-painted ailerons. The lateral nozzles are invisible in this view.



Right: An R-40TD on a ground handling dolly fitted with annular securing clamps and a protective cap on the nose. The R-40TD can be carried by the MiG-25PD and the MiG-31.

target lock-on range, enhanced guidance accuracy and high ECM resistance. To ensure that the seeker head will not start acting up due to the immense kinetic heating at hypersonic speeds the foremost body section is provided with an environmental control system and the seeker head's radome (or sensor cap, depending on the type) is made of specially developed heat-resistant materials. The radar seeker head has a feature allowing the R-40R to be used against ECM aircraft equipped with active jammers.

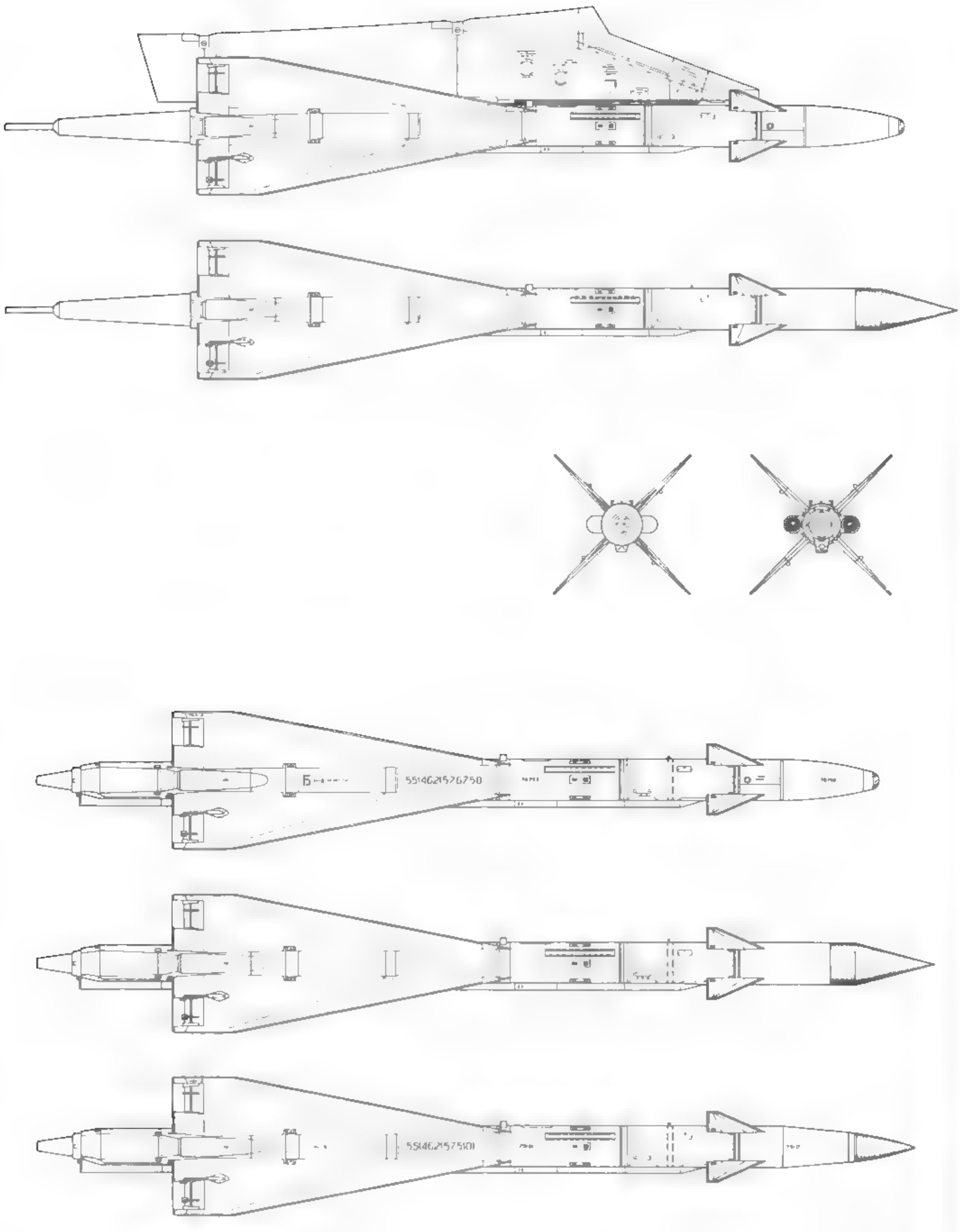
Section 2 carries the rudders whose actuators are powered by rocket motor bleed gases. Thus the R-40 dispenses with the customary compressed air bottles. On the R-40T this section also accommodates a supply of liquid nitrogen for the IR seeker head's cooling system.

Section 3 houses a combined radar/optical proximity fuse – the first of its kind in the Soviet Union. It features independent radar and optical channels giving it enhanced ECM resistance; hence Section 3 incorporates both aerials for the radar channel and viewing ports for the optical channel. The autopilot is located further aft inside Section 3.

The next section accommodates a solid-fuel rocket motor with lateral jetpipes. For the first time in Soviet practice a high-impulse mixed fuel was used. The rocket motor housing incorporates the mounting lugs and wing attachment fittings. The wings themselves have delta planform and incorporate ailerons.

The tail section houses the explosive charge, the aileron actuators, the turbogenerators powered by rocket motor bleed gases, the receiver aerial of the fuse's radar channel, a tracer and other equipment. Another 'first' in Soviet missile design practice is that the R-40's warhead generates a directional dense stream of fragments to inflict maximum damage. A ventral fairing running from Section 2 to the tailcone

An R-40RD (left) and an R-40TD under the port wing of a MiG-25PD. This view shows the rocket motor nozzles and the short but thick tail section of the upgraded R-40RD/TD as opposed to the long pointed tailcone of the R-40R R-40T; the rear probe aerials are covered by protective caps.



Top to bottom An R-40T missile on an APU-84-46 pylon; the R-40T; front, rear and side views of the R-40TD, the R-40RD, and an as-yet unidentified version of the latter with a different radar seeker head

houses the waveguide of the receiver aerial, turbogenerator feed pipelines and more.

While the missile is on the wing, the R-40's equipment bays are cooled in flight by evaporation of chlorofluorocarbon (the cooling agent used in refrigerators). A supply of CFC is kept for this purpose in bottles housed in the MiG-25's missile pylons.

The R-40 missile joined the inventory as part of the MiG-25-40 long-range aerial intercept weapons system. The MiG-25P interceptor carries four missiles – a mix of SARH and IR-homing versions – on underwing APU-84-46 launch rails (the figures refer to the product codes of the aircraft and missile respectively). R-40T missiles are carried on the inboard hardpoints only. The inner and outer pylons have different dimensions and feature structural differences; among other things, the larger inboard pylons house more compressed air bottles than the outer ones. The missiles can be fired both singly and in pairs, with a short interval between the launches

The MiG 25-40 weapons system enables head-on attacks if the target is flying at 2,500-27,000 m (8,200-88,580 ft) with a speed of 1,000-3,500 km/h (621-2,174 mph). In pursuit mode it can attack targets doing 800-2,300 km/h (496-1,428 mph) at 800-30,000 m (2,620 98,425 ft)

Dummy versions of the R-40R and R-40T have been developed for training interceptor pilots on the dual-control MiG-25PU Designated UR-40R and UR-40T respectively (UR = *oochebnaya raketa* – training missile), they are dimensionally and aerodynamically identical to the real thing and weigh the same but have neither equipment nor a rocket motor

R-40D air-to-air missile

The upgraded R-40D missile, which comes in semi-active radar homing (R-40RD) and IR-homing (R-40TD) versions, was brought out concurrently with the upgraded MiG-25PD interceptor. In both cases the D suffix means *dorabotannaya* (or *dorabotannyy*, respectively) – updated or modified. The development of these versions was prompted by an unfortunate event – the notorious defection of Lt Viktor Belenko to Hakodate, Japan, in a MiG-25P on 6th September 1976 which allowed the West to examine the then-latest Soviet fighter in the tiniest detail. To offset the damage done by Belenko's treachery, a large-scale upgrade programme involving numerous weapons systems was launched immediately - and of course it concerned the MiG 25P as well

The following table illustrates the performance of the R-40.

	R-40R	R-40T
Product code	*Izdeliye* 46R	*Izdeliye* 46T
Codename		
US	AA-6	AA-6
NATO (ASCC)	Acrid	Acrid
Service entry	1970	1970
Calibre	300 mm (11 13/16 in)	300 mm (11 13/16 in)
Length overall	6.76 m (22 ft 2⅛ in)	6.36 m (20 ft 10⅜ in)
Wing span	1.4 m (4 ft 7⅛ in)	1.4 m (4 ft 7⅛ in)
Launch weight, kg (lb)	455 (1,003)	468 (1,031)
Warhead weight, kg (lb)	38 (83)	38 (83)
'Kill' range, km (miles)	2-30 (1.24-18.6)	2-30 (1.24-18.6)
'Kill' altitude, m (ft)	2,500-27,000 (8,200-88,580)	800-30,000 (2,620-98,425)
Launch rail type	APU-84-46	APU-84-46
Missile platform	MiG 25P, MiG 31	MiG 25P, MiG-31

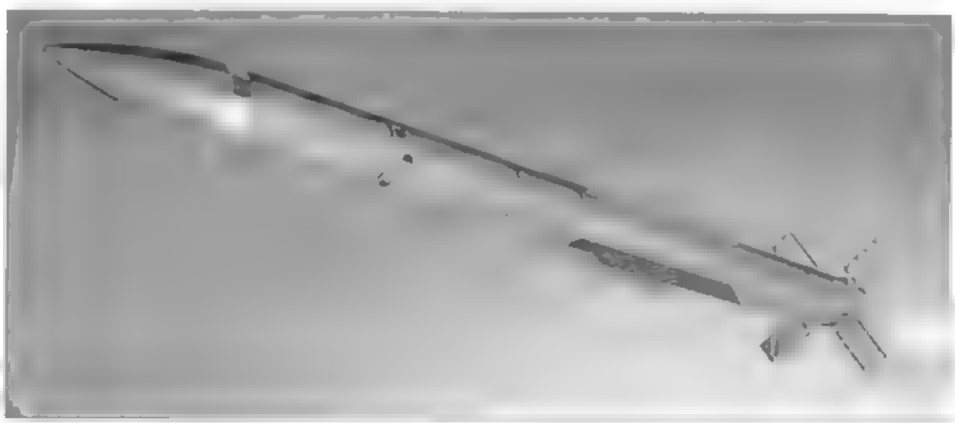
Despite the fact that the MiG-25 hijacked to Japan had been 'clean' (that is, without external stores) and the West had not laid hands on the R-40, the changes made to the MiG-25PD's avionics (first and foremost the fire control radar) required some changes to the missile as well These were only minor, concerning the equipment in the tail section; as a result, this section was shortened by 385 mm (1 ft 3 5/32 in), with a corresponding reduction in overall length. Conversely, the ventral wiring and piping conduit was greatly extended. Even though the missiles remained largely unchanged, the combat capabilities of the MiG-25PD were considerably increased thanks to the new mission avionics. Subsequently the R-40D found use on the MiG-31 interceptor evolved from the MiG-25PD

The R-40RD is 6 376 m (20 ft 11 in) long, the R-40TD is noticeably shorter at 5 98 m (19 ft 7 7/16 in). The launch weight is identical for both versions, being 470 kg (1,036 lb); so is the calibre (300 mm) and the wing span (1 45 m/4 ft 9 in).

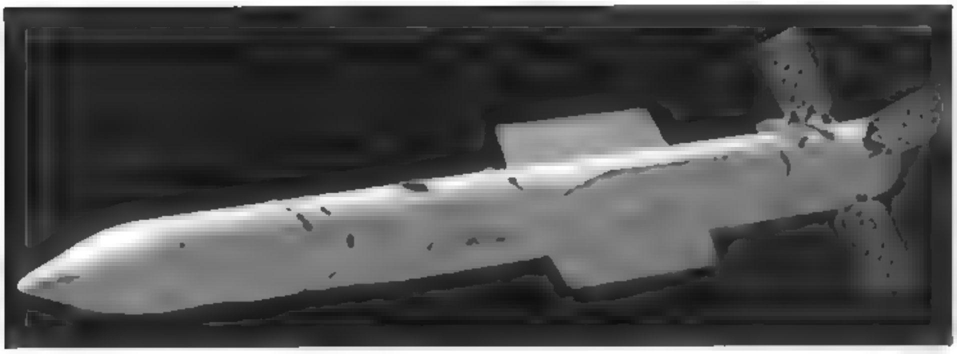
R-77 (RVV-AE) air-to-air missile

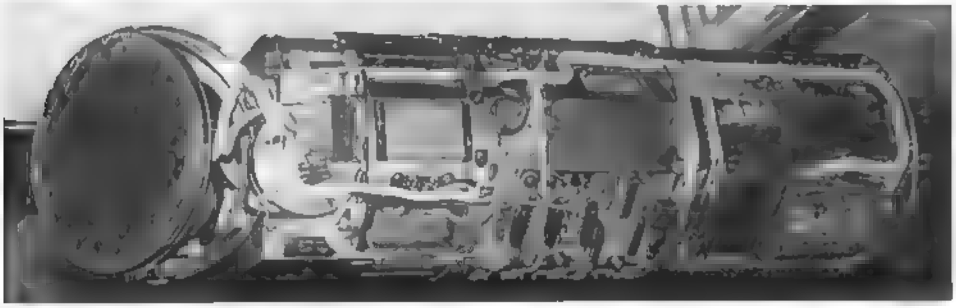
The R-77 – or RVV-AE (the export designation by which it was known for years until the Russian designation was revealed) – was created by GMKB Vympel for the MiG-29M, MiG-31M, Su-27M (Su-35) and other advanced Generation 4+ fighters. It underwent comprehensive testing together with the MiG-29M The RVV-AE acronym stands for *raketa **'vozdookh-vozdookh'**, aktivnaya, **eksportnaya*** – air-to-air missile, active [radar homing], export version.

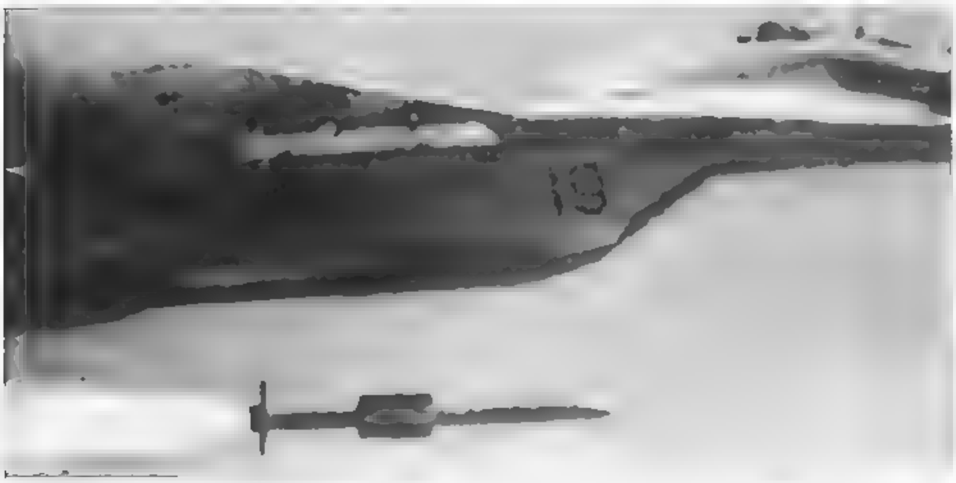
The R-77 (RVV-AE) can be used effectively for attacking tactical aircraft making evasive manoeuvres with up to 12 Gs, including aircraft embodying stealth technology. It can also be used against strategic bombers, helicopters in motion and at the hover, cruise missiles and even surface-to-air and air-to-air missiles. The targets can be attacked from any angle, around the clock and in any weather; 'look-down/shoot-down' mode over land or water and enemy ECM are no problem either

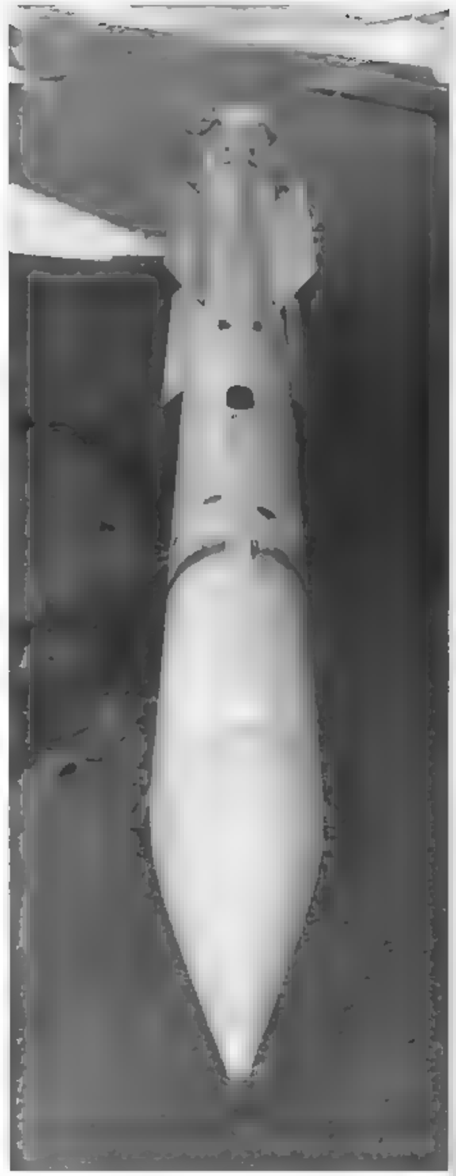


An artist's impression of the R-77 (RVV-AE) missile in action. The shiny chrome-plated ring aft of the radome is not found on the real thing.









The R-77 is a 'fire and forget' weapon and can be used for attacking multiple targets. It utilises inertial guidance at the initial stage of the trajectory, with active radar homing at the terminal guidance phase.

The R-77 represents a qualitatively new stage in Russian missile design. It is intended for dedicated interceptors in PVO service, as well as for tactical aircraft and attack helicopters. A very distinctive trait of the R-77 is the use of lattice rudders, a feature hitherto unseen anywhere in the world. They generate very little drag when oriented along the slipstream but the drag increases dramatically when the rudders turn, creating side-forces.

Top left and above: Two inert demonstration examples of the R-77 (RVV-AE). The lattice-like rudders are clearly visible, as are the proximity fuse windows a short way aft of the radome.

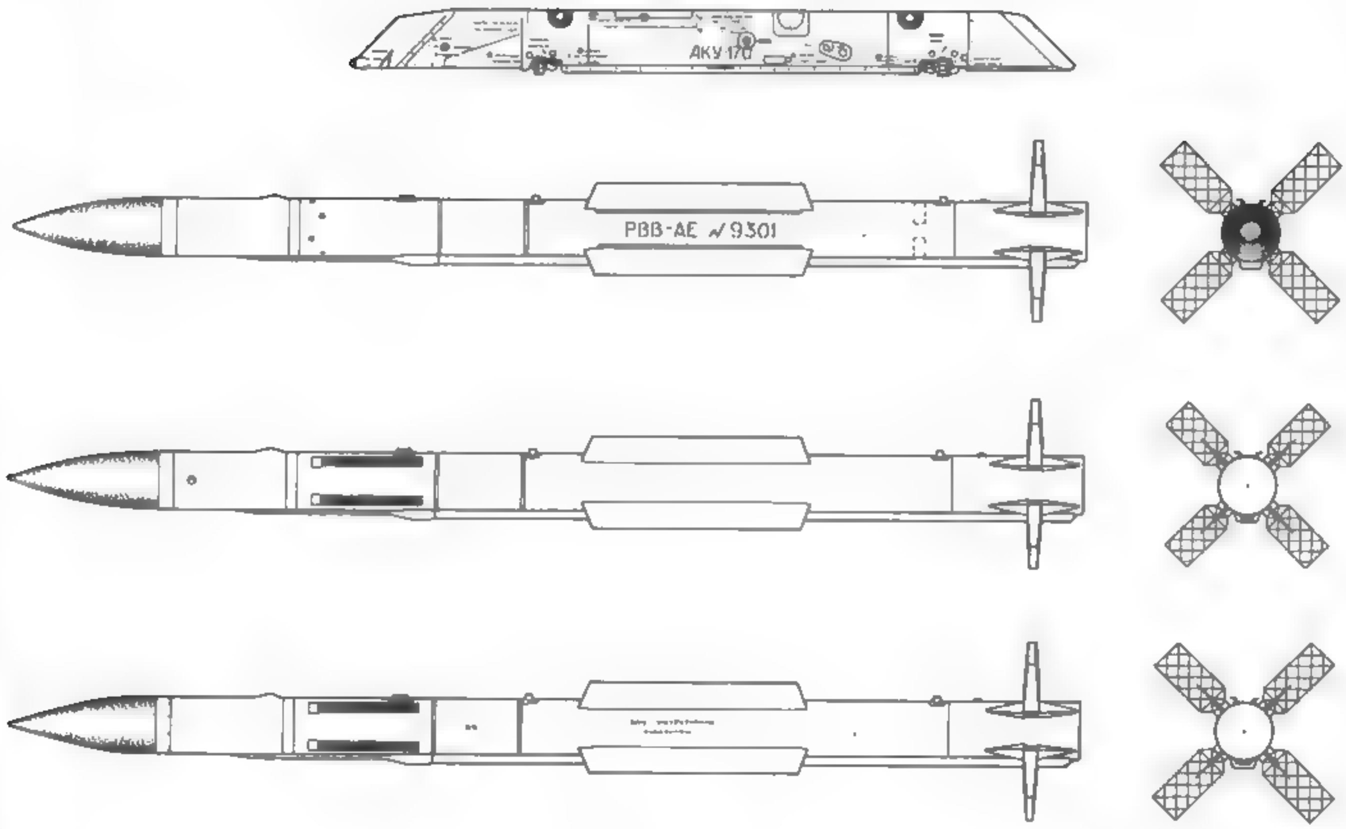
Centre left. The R-77's active radar seeker head with the outer shell and radome removed, showing the fully articulated radar scanner.

Above left. Live tests of the R-77 were performed on one of the original MiG-29 prototypes known at the Mikoyan OKB as 'aircraft 9-19' and appropriately coded '19 Blue'.

Left. An inert RVV-AE (with protective covers over the radome and proximity fuse windows) on an AKU-170 launch rail is seen here on the outermost port wing hardpoint of an Indian Air Force Su-30MKI multi-role combat aircraft. A wingless R-60MU acquisition round is fitted to the wingtip launch rail.

Opposite page, above, top to bottom. The AKU-170 launch rail, side and rear views of the RVV-AE; front and side views of two R-77 versions (the lower one has larger rudders).

Right. The sixth prototype MiG-31M ('056 Blue') with four inert R-77s under the wings.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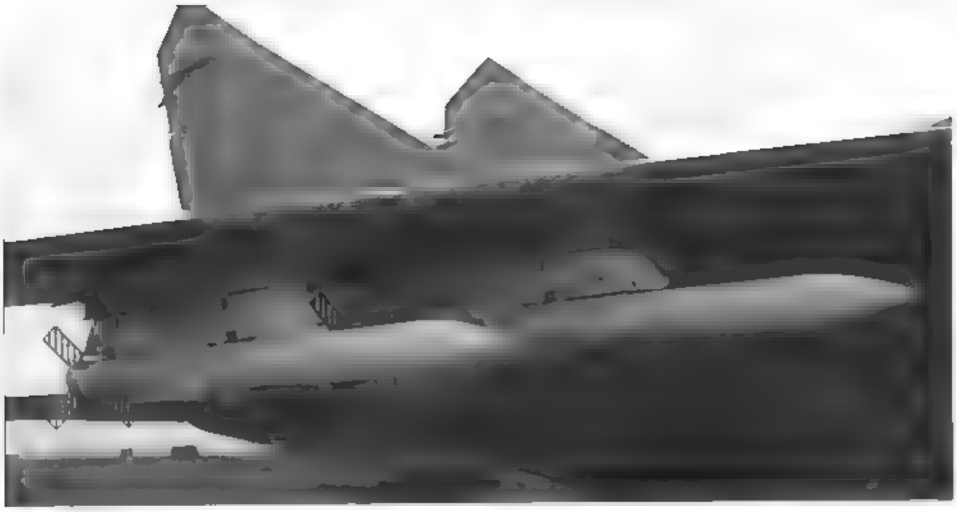
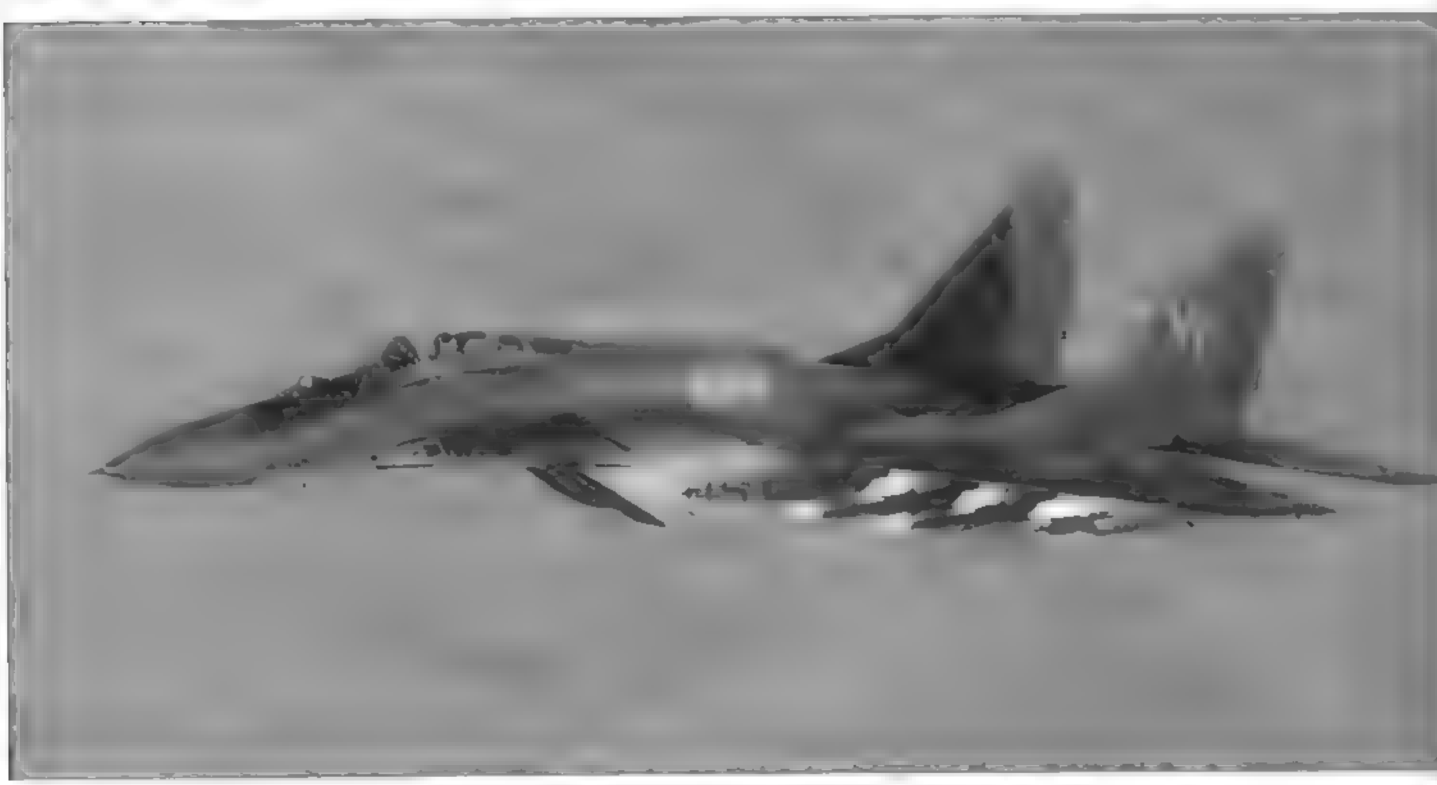


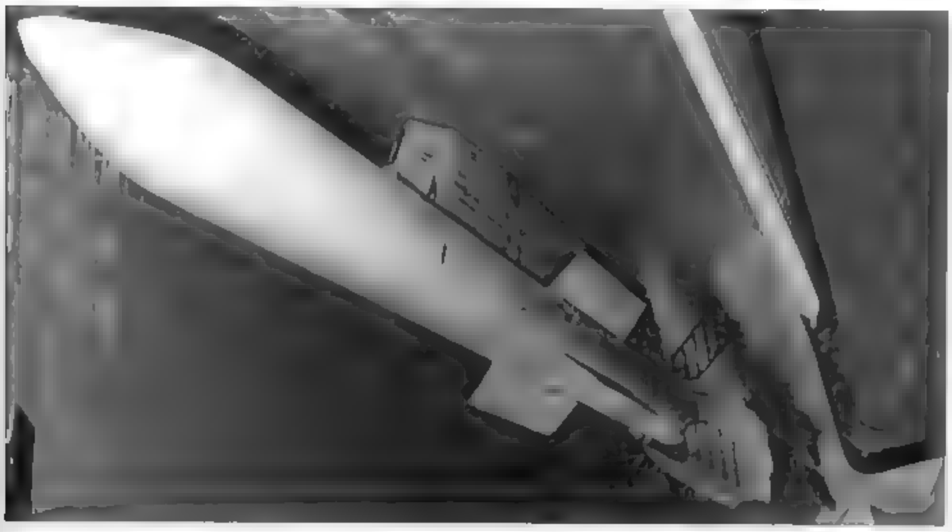
The R-77's closest Western equivalents are the AMRAAM (it is not for nothing that the R-77 has been dubbed 'Amraamski', after all!) and the MATRA Mica. While having a slightly lower launch weight than either of its Western counterparts, it has longer range and superior ability to destroy actively manoeuvring or low-flying targets. This gives aircraft armed with the R-77 (RVV-AE) an advantage over fighters toting the AMRAAM or Mica.

The missile is carried on the specially developed AKU-170 ejector rack. The R-77 is 3.6 m (11 ft $9\frac{3}{4}$ in) long, with a body diameter of 200 mm ($7\frac{7}{8}$ in); the strake-like wings span 0.45 m (1 ft $5\frac{23}{32}$ in), while the rudder span is 0.76 m (2 ft $5\frac{59}{64}$ in), although some examples feature rudders with a reduced span of 0.703 m (2 ft $3\frac{43}{64}$ in). The launch weight is 175 kg (385 lb); the permitted launch range is anything from 300 m to 90 km (1.86-56 miles). The NATO codename is AA-12 *Adder*

Two close-ups of the paired R-77s under the wings of MiG-31Ms '056 Blue' (above left) and '057 Blue' (left). The missiles are dummies in both cases, this is obvious in the photo on the left, as the missiles have 'solid' rear ends with no rocket motor nozzles!

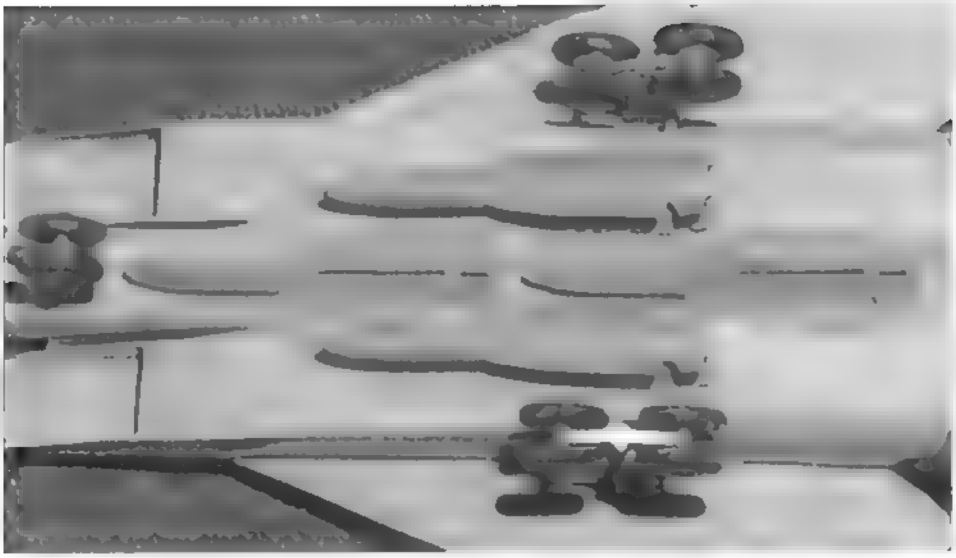
Below: This camouflaged MiG-29 *Fulcrum-C* (*izdeliye* 9.13) coded '05 Blue' was used for testing the R-77 at the Air Force Research Institute in Akhtoobinsk. No fewer than three missiles are visible here; the one on the outermost pylon is painted red.



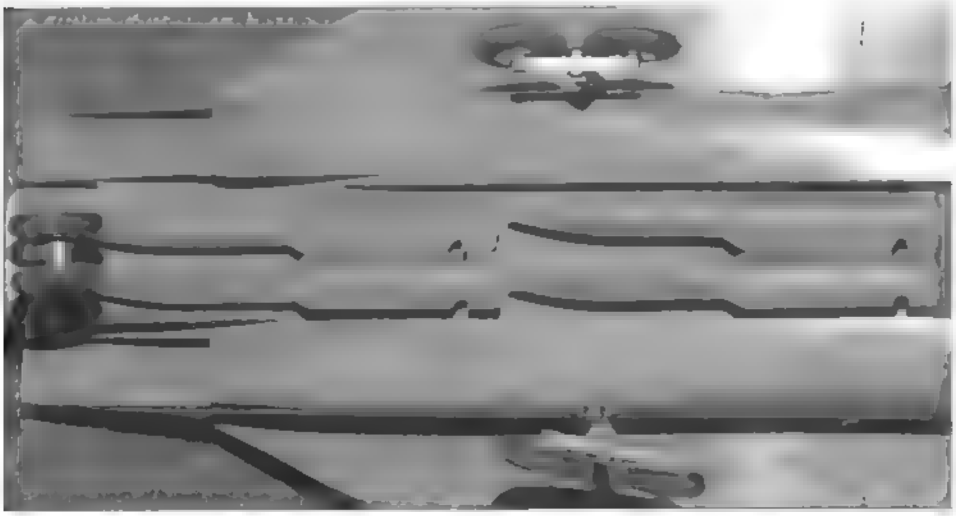


Top: A diagram illustrating the guided air-to-air weapons that can be carried by the Su-27SKM multi-role tactical fighter. These include up to six R-77s (RVV-AEs) on the inboard wing pylons, under the engine nacelles and on the centreline.

Above, above right and right. Close-ups of the R-77s (dummies again) on the tandem centreline hardpoints of the Su-27SKM.



Left: A desktop model of a preliminary design project version of the Ye-155MP (the future MiG-31), showing four R-33 AAMs in a diamond arrangement. Note the large fins with curved leading edges.



Below left. A model of another PD project version of the Ye-155MP (the '518-55') The R-33s shown here and their arrangement under the aircraft are much closer to the real thing, except that the MiG-31 does not have a recessed weapons bay.

R-77M (RVV-AE-PD) air-to-air missile

With future Russian fifth-generation fighters in mind, GMKB Vympel is working on an advanced next-generation version of the R-77 (RVV-AE) tentatively designated RVV-AE-PD The last two letters stand for *pryamotochnyy dvigatel'* (ramjet), since the missile is indeed powered by a solid-fuel ramjet, the engine breathes through four square-section air intakes with forward-swept leading edges located in the planes of the wings and rudders. The new powerplant is to give the missile significantly greater range as compared to the basic R-77.

The RVV-AE-PD has a launch weight of 225 kg (496 lb) and is 3.7 m (12 ft 1$\frac{43}{64}$ in) long

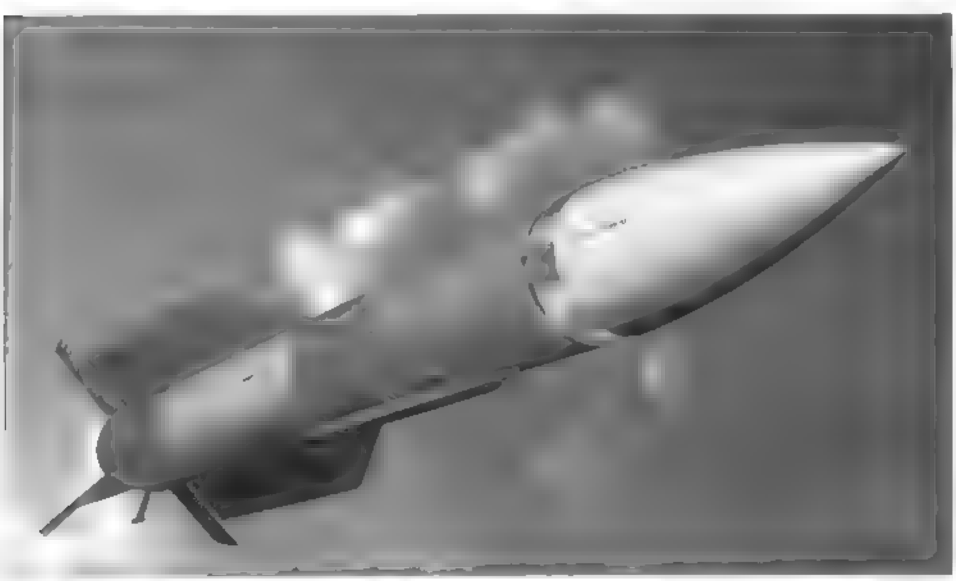
R-33 (*izdeliye* 410) and R-33E air-to-air missiles

The R-33 (*izdeliye* 410) long-range AAM was specially developed by GMKB Vympel and placed into production for the aerial intercept weapons system based on the MiG-31 *Foxhound* heavy interceptor. A high-powered ultra-long-range variant of this missile was designated R-33E

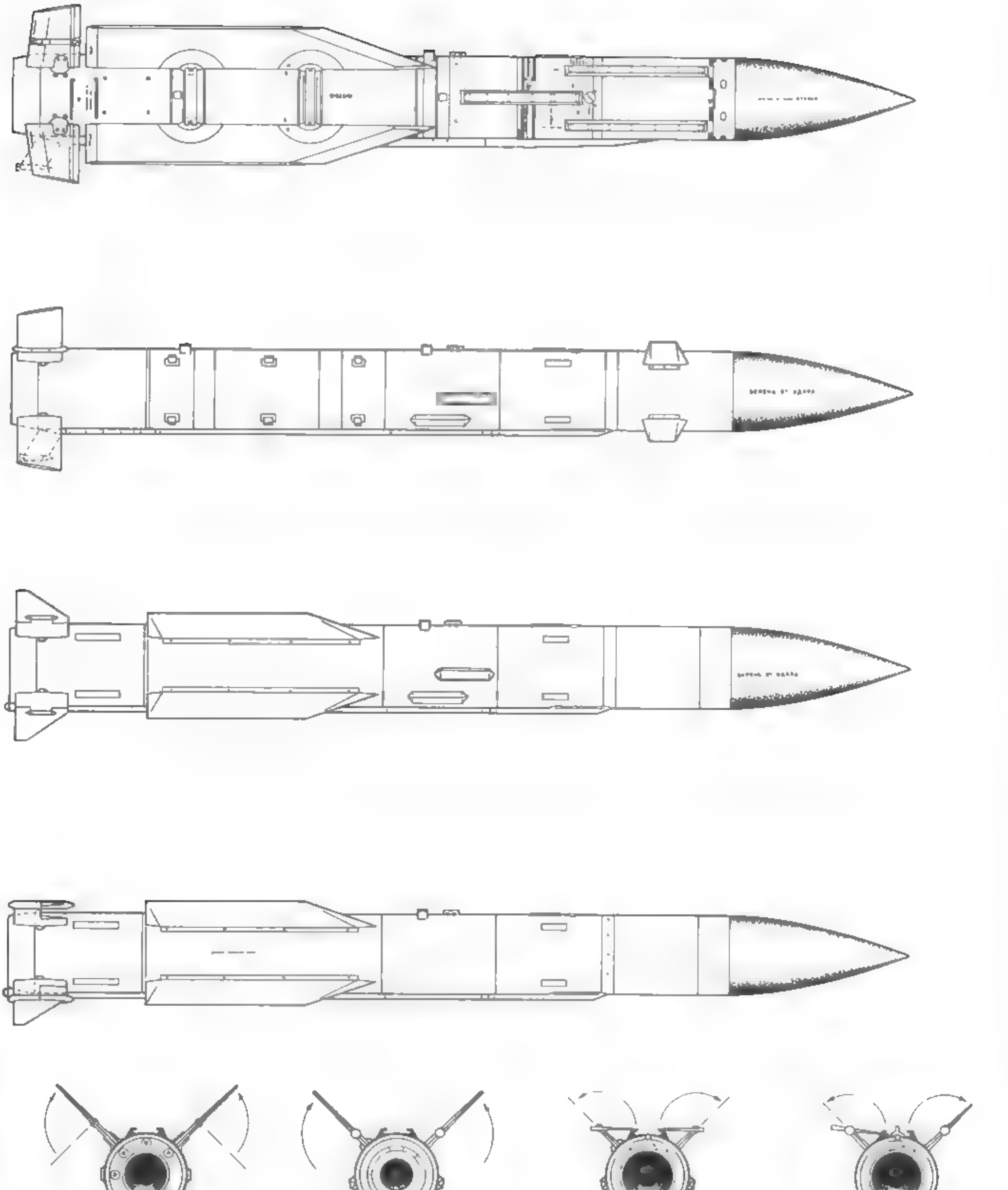
The R-33 is the MiG-31's principal weapon. Four of these missiles are carried in tandem pairs semi-recessed in the interceptor's fuselage. During launch the missiles are propelled clear of the aircraft by AKU-410-1 pyrotechnically-actuated pantographic ejector racks. The semi-recessed carriage makes it impossible to use 'real' wings, so the R-33's fins look like long, narrow strakes. The rudders have longer span, so the upper portions of the top pair of rudders fold against the body for the same reason, unfolding before the rocket motor ignites.

Long range is achieved thanks to a two-stage guidance system, with inertial guidance and mid-course correction at the initial stage, followed by semi-active radar homing after the all-aspect radar seeker head achieves a lock-on. At the design stage it was envisaged that the R-33 would mostly be used against cruise missiles and strike aircraft penetrating Soviet air defences at low altitude under ECM cover. Hence the missile's control system was designed to give 'look-down/shoot-down' capability and discern between the target and false radar returns generated by active ECM, as for passive ECM the radar seeker head is immune to them

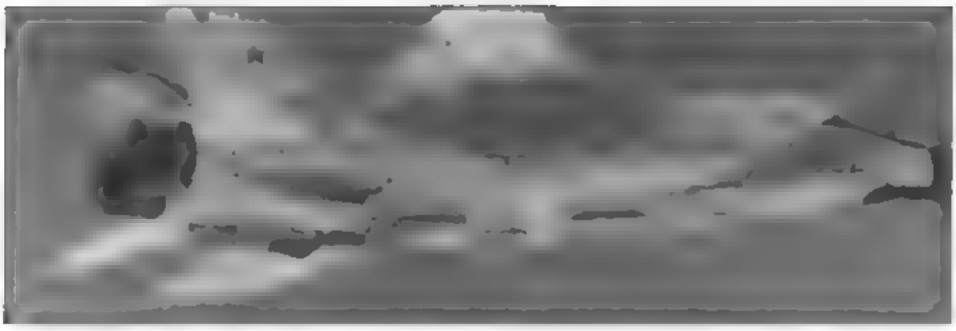
The R-33/R-33E is capable of destroying targets, including terrain-following cruise missiles, flying over various backgrounds at altitudes from 25-50 m (80-160 ft) to 26,000-28,000 m (85,300-91,860 ft) and speeds up to 3,000 km/h (1,863 mph). The targets can be engaged from any angle, around the clock and in any weather. The powerful

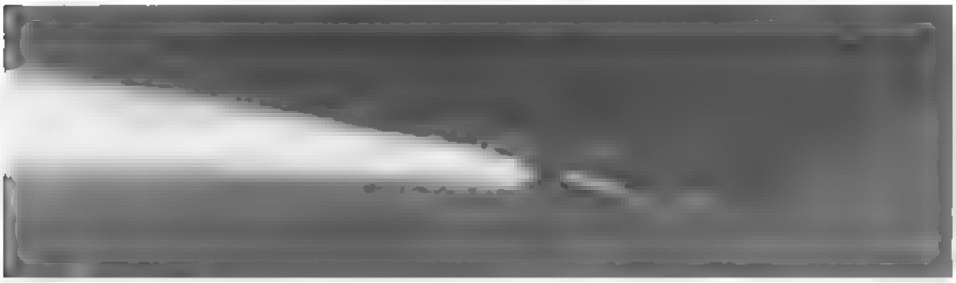


A picture of the R-33 from a GMKB Vympel ad, showing the strake-like fins and the folding upper pair of rudders.



Top to bottom The R-33 and three different versions of the R-37 (the wingless version was carried on the centreline by one of the MiG-31M prototypes) The rear views (left to right) show these four missiles 'in order of appearance'





solid-fuel rocket motor, which also supplies electric power by means of turbogenerators, provides a maximum 'kill' range of 1,200 km (745 miles) and enables destruction of targets flying up to 10,000 m (32 810 ft) above or below the MiG-31's own flight level

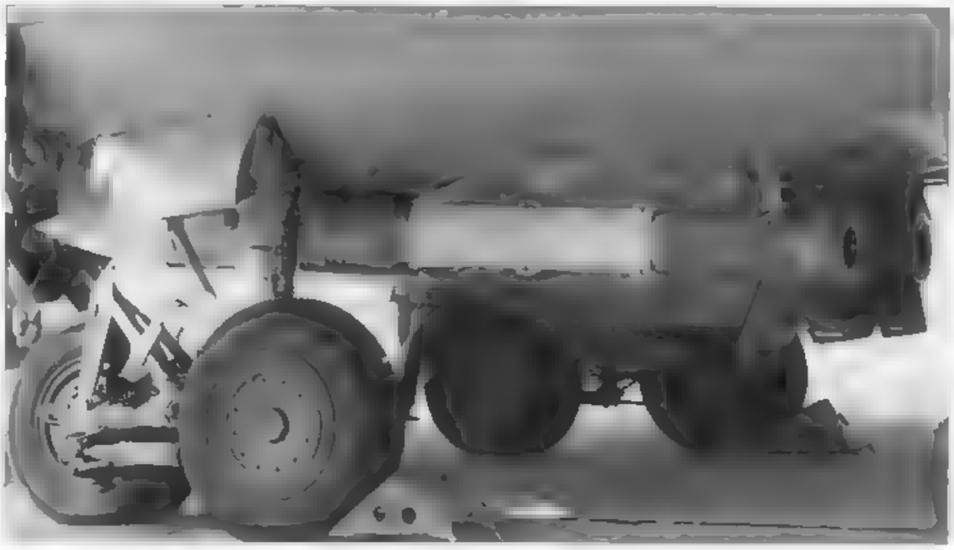
The very sensitive radar seeker head can acquire and track various types of aerial targets, including those flying at ultra-low level or in clouds of chaff, as well as aircraft equipped with active jammers of assorted types. The R-33's Doppler semi-active radar seeker head, together with a feature of the MiG-31's radar, enables several aircraft to simultaneously attack multiple targets each without 'getting in each other's way'. Quite simply, the Model 8B fire control radar has a special emitter operating in quasi-continuous mode, transmitting coded signals to tell the missile the tactical code of the fighter it was launched from and the number of the target, so that 'each missile knows its mark and does not go for somebody else's target. No pre-tuning of the radar seeker head prior to launch is necessary

The 47-kg (103-lb) high explosive/fragmentation warhead generates a narrow cone of fragments. It is integrated with the pulse-type active radar proximity fuse in the

Left: This sequence of stills from a cine film shows one of the MiG-31 development aircraft participating in the manufacturer's flight test and state acceptance trials programmes ('302 Blue', f/n 0302) launching an R-33 from the port rear fuselage hardpoint. Note how the missile falls away from the aircraft before ignition The powerful rocket motor of the R-33 spouts terrific flames.

Below: An R-33 on display at one of the Moscow airshows Note the arrangement of the three proximity fuse aerials on each side.

Right: The forward pair of R-33s is truly semi-recessed, the missiles' large radomes flanking the nosewheel well and the upper fins being accommodated in special cutouts in the belly.



Below right. The rear pair of R-33s is, in fact, carried externally in a nose-up attitude The folded upper rudders are visible here.

Bottom right: The MiG-31's complement of R-33s on their individual dollies.

best possible way The fuse uses the data and commands generated by the seeker head, being activated when the target is no more than 2 km (1.24 miles) away; this increases its ECM resistance in an active ECM environment or in clouds of chaff

In day-to-day operational service the R-33/R-33E does not require any retuning Checks of the missile's guidance system need to be made just once every 12 months, using special ground test equipment

The R-33 is a second-generation AAM and is the Soviet counterpart of the American AIM-54 Phoenix. It can destroy targets making evasive manoeuvres with up to 4 Gs The R-33E is 4 15 m (13 ft 7$\frac{25}{64}$ in) long, with a calibre of 380 mm (1 ft 2$\frac{31}{32}$ in) and a wing span of 0 9 m (2 ft 11$\frac{13}{32}$ in); the rudder span is quoted variously as 1.11 m or 1.18 m (3 ft 7$\frac{45}{64}$ in or 3 ft 10$\frac{29}{64}$ in). The launch weight is 490 kg (1,080 lb); maximum 'kill' range is 120 km (74.5 km) and maximum target altitude is 28,000 m (91,860 ft)

The R-33's NATO codename is AA 9 *Amos*

R-33S air-to-air missile

This version was developed for two updated versions of the *Foxhound*, the MiG-31B and MiG-31BS. Unfortunately, again the development of these variants was a forced measure in the wake of a devastating leak In 1985 one A. Tolkachov, a hired agent working for one of the Western intelligence agencies, was arrested by the KGB in Moscow, it was established that he had supplied his overseas 'employers' with highly sensitive information on the MiG-31's avionics and armament Tolkachov's actions turned out to be even more damaging than Belenko's defection; but then, he also got caught, tried and executed for his trouble

Now the aviation and armament design bureaux were compelled to step up their efforts to give production MiG-31s a new armament system. These culminated in the MiG-31B equipped with an improved radar having even better ECM resistance and armed with upgraded R-33S missiles. The new mission avionics, primarily the digital data processing system, increased the upgraded fighter's combat potential by some 30%.

Above: 202 Blue', the fourth production MiG-31 (c/n N69700102176, f/n 0202), carrying four R-33s; the two on the starboard side are zebra-striped inert rounds.
Below: The MiG-31B prototype ('592 Blue', f/n 5902) carrying four R-33s and two dummy R-40RDs under the wings. The R-40RD is never carried by the MiG-31

Above and below: This MiG-31 ('77 Blue') was displayed at one of the 'open doors days' at Savasleyka AB near Nizhniy Novgorod with this impressive weapons array – two R-40TDs on the massive dolly in front, four R-33s (with protective covers on the radomes), four R-60Ms and cannon ammunition.

R-37 air-to-air missile

This ultra-long-range AAM, a descendant of the R-33, was developed by GMKB Vympel specifically for the 'second-generation *Foxhound*' – the extensively redesigned MiG-31M interceptor Its maximum launch range is an impressive 300 km (186 miles) Apart from the greatly improved performance, the R-37 differs from the R-33 in having a totally different control system: the missile is designed to be statically unstable in flight in order to enhance its agility Also, the R-37 has active radar homing at the terminal guidance phase Finally, the complement of missiles is increased from four to six – the R-37s are semi-recessed in the MiG-31M's belly in two rows of three, the centre missile being placed farther aft

The R-37 is likewise 4.15 m (13 ft 7⅜ in) long, with a calibre of 380 mm (15 in), wing span is reduced to 0.7 m (2 ft 3½ in), although one version lacks wings altogether, and the rudder span is 1.1 m (3 ft 7 45/64 in) on some examples or 0.98 m (3 ft 2 37/64 in) on others

Above left and below: Six R-37 missiles under the sixth prototype MiG-31M ('056 Blue'). The close spacing of the missiles carried three-abreast is clearly visible. Interestingly, the nose gear doors feature special bulges at the rear to fit around the radome of the centre missile.

Left: six R-37s under the final MiG-31M prototype, '057 Blue' (c/n N72100106137)

GUIDED DEATH FROM THE SKIES

On 13th May 1946 the Soviet Council of Ministers issued a directive ordering the commencement of development work on rocket and missile weapons systems. This document kicked off a far-reaching reorganisation of the Soviet defence industry. A whole series of new design bureaux, manufacturing plants and research institutes was established, while some of the existing ones, including MAP's NII-1, were reorganised. Among other things, plant No 293 in Khimki, a northern suburb of Moscow, was transformed from a branch of NII-1 into a separate design bureau (OKB-293) under Matus R. Bisnovat who was also appointed the plant's director (see Chapter 1).

As noted in the preceding chapter, OKB-293 had previously existed as Viktor F. Bolkhovitinov's design bureau; it had been absorbed by NII-1 as a branch office in 1944. Bolkhovitinov had been appointed the Institute's Vice-Director for Science, while OKB-293 engineers Aleksandr Ya. Bereznyak and Aleksey M. Isayev (the men responsible for the BI-1 rocket-propelled fighter of 1941) became head of the branch office's design bureau and head of the liquid-propellant rocket motor design section respectively. Now, after the 1946 reorganisation, Bolkhovitinov left the institute to teach at the Air Force Academy named after Nikolay Ye. Zhukovskiy, while Bereznyak was appointed Deputy Chief Designer at OKB-2 where captive German engineers developed rocket-propelled aircraft for the Soviet Union.

In 1948 the re-established OKB 293 began development of the Shtorm (Sea Storm) coastal defence missile system; the subsonic anti-shipping missile forming its core was based on Bolkhovitinov's '5' rocket-propelled experimental aircraft. Other organisations received similar assignments. For example, GSNII-642 developed the KSShch anti-shipping cruise missile (krylahtyy snaryad 'Shchooka' – 'Pike winged missile'). OKB-51 (the original design bureau of Vladimir N. Chelomey that was subsequently dissolved, re-forming as the Sukhoi OKB) developed the 10Kh/14Kh/16Kh family of jet-powered cruise missiles derived from the German V1, while Artyom I. Mikoyan's OKB-155 joined forces with the SKB-1 specialised design bureau (*spetsi-ahl'noye konstrooktorskoye byuro*) to create the KS-1 anti-shipping cruise missile. In 1953, however, work in this field was stopped by government orders everywhere except the Mikoyan OKB – ostensibly in order to concentrate the work in the hands of a single team (the SKB-1/ OKB-155 tandem). In reality political motives were involved, the air-to-surface missile design programmes were supervised by Sergey L. Beria, son of Lavrentiy P. Beria. Interestingly, the early Soviet air-to-surface missiles were massive weapons designed either for anti-shipping strikes (in order to foil hypothetical US Navy attacks on the Soviet coasts) or for attacking the enemy's political and industrial centres. This meant they could only be carried by heavy or medium bombers. It was not until the mid-1960s that tactical ASM development began in the Soviet Union – and new design bureaux became active in this field.

Mikoyan's Cruise Missiles

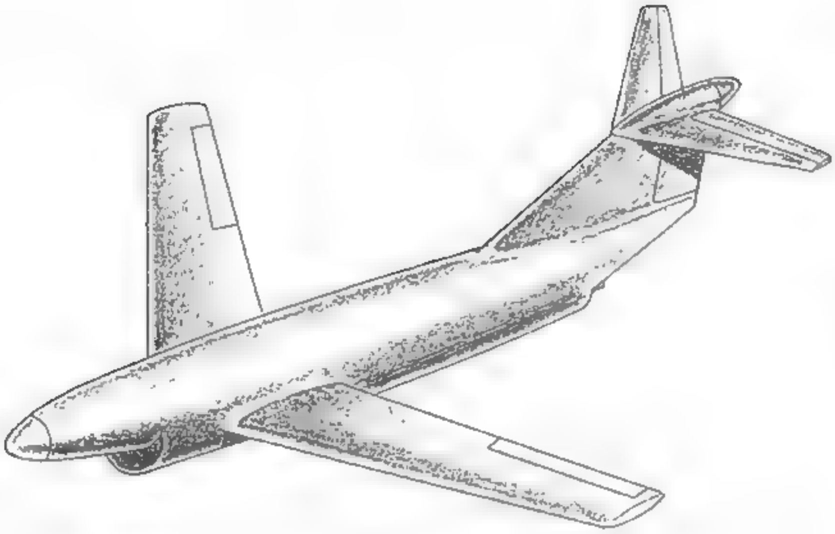
Cruise missile development at Artyom Ivanovich Mikoyan's OKB-155, which, as already mentioned, specialised in fighter design (and it still does), was the responsibility of Deputy Chief Designer Mikhail Iosifovich Gurevich. In 1953 the disbanded OKB-2 mentioned above (the German team at the Experimental Plant No.1 developing rocket-propelled aircraft) was merged into OKB-155 to become an affiliate. Aleksandr Ya. Bereznyak became Chief Designer of this branch. Designated OKB-2-155, the new branch was tasked with developing air-launched cruise missiles powered by liquid-propellant rocket motors; eventually it broke away from the Mikoyan OKB in 1967 and was known henceforth as MKB Raduga.

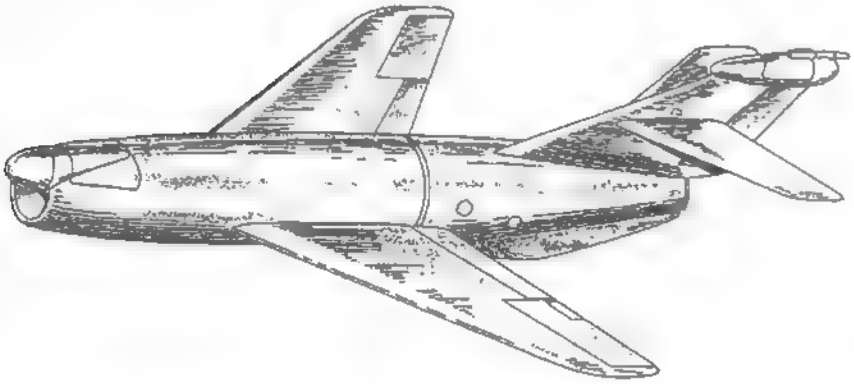
KS-1 Kometa (KS) cruise missile

This was the Soviet Union's first anti-shipping cruise missile (or, in the day's terminology, *samolyot-snaryad* – lit. 'missile aircraft') to achieve production and service. Development began in 1947 at the direct orders of Lavrentiy P. Beria who, in addition to his main duties as Minister of the Interior, rendered a lot of support to the development of new weapons systems (including nuclear ones). The reason for Beria's interest in this particular case, however was strictly mundane. his son Sergey, a signals corps major, was then due to graduate from a military academy and the anti-shipping missile was the subject of his graduation paper. The project was supervised by Col. P. N. Kooksenko. Hence the abovementioned SKB-1 specialised design bureau was formed for the purpose of developing the missile's guidance system (with Sergey L. Beria's direct participation); responsibility for the missile itself was assigned to the Mikoyan OKB.

The original project of 1948 designated KS (for *Kometa-snaryad* – 'Comet-missile') was rather different from the missile that eventually emerged. The swept wings were positioned well forward along the fuselage length and the missile had a T-tail; the air intake of the RD-20 axial-flow turbojet engine (a reverse-engineered version of the BMW 003A) was located under the centre fuselage, and the resulting long 'snout' housing the guidance system radome gave the thing a cartoon-like appearance. The stipulated range at a launch altitude of 4 000 m (13,120 ft) was 195 km (120 miles). However, the project review panel discovered numerous faults in the project and axed it.

The next project submitted in November 1949 drew heavily on experience with the MiG-15 jet fighter. Basically the missile was a scaled-down MiG-15 with a lower-powered RD-500K centrifugal-flow turbojet (a licence-built version of the Rolls-Royce Derwent V), featuring mid-set swept wings and swept cruciform tail surfaces. The greatest difference as far as the airframe structure was





Left: An artist's impression of the original KS cruise missile project of 1948. Note the ventral placement of the air intake, the moderate wing sweep, the sharply tapered fin and the bulbous fairing at the fin/tailplane junction for the receiver antenna of the mid-course guidance system. The cropped tailcone in the centre of the RD-20 turbojet's nozzle is just visible under the tail.

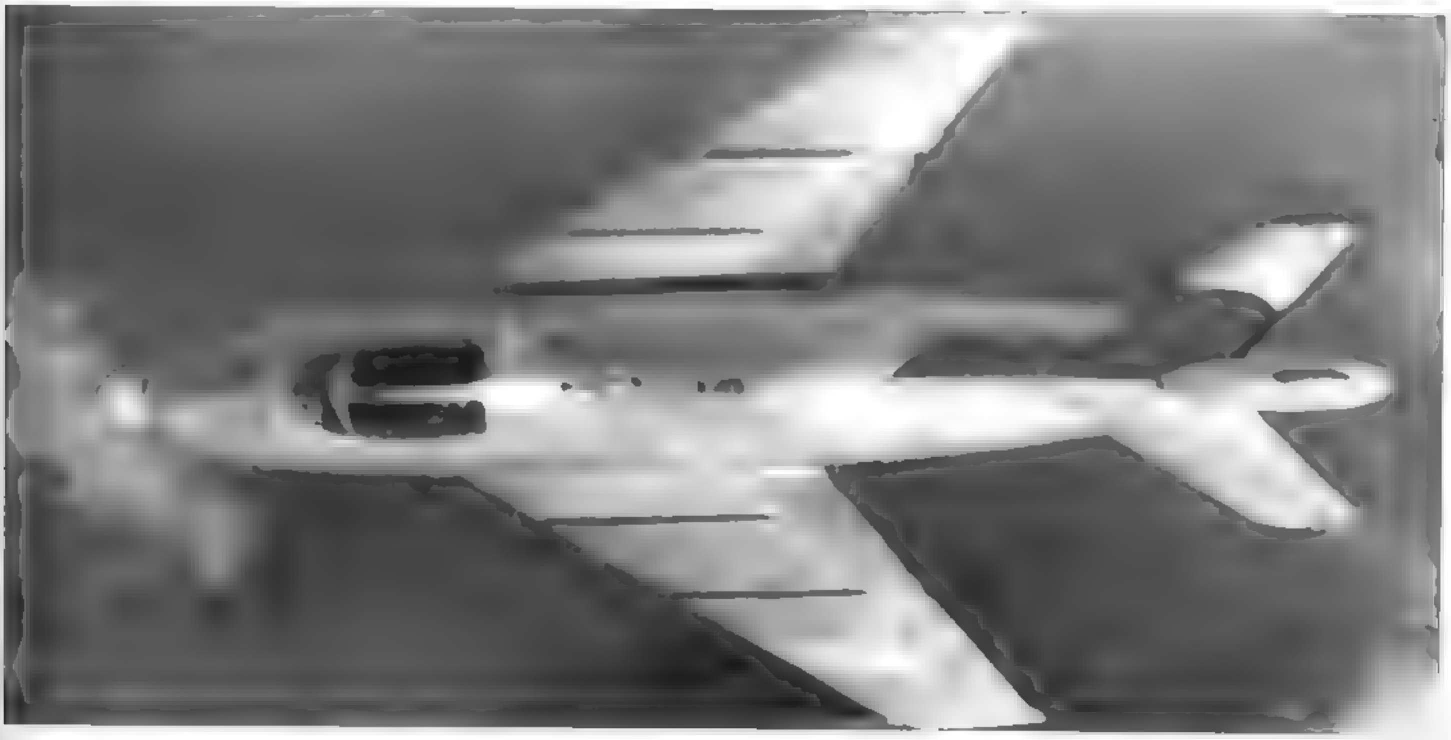
Below left: An early artist's impression of the fully redesigned KS-1 project drawing heavily on the MiG-15 fighter's design. This drawing shows the fuselage break point facilitating manufacture and engine installation – and, incongruously, wing flaps which are not found on the real thing. Neither were the outward-canted strakes under the rear fuselage fitted to the actual missile.

Below: The bizarre MiG-9L (*izdeliye* FK) guidance system testbed for the KS-1 missile. The aircraft featured a homing system antenna in a bullet-shaped radome above the air intake and a cigar-shaped fairing for the mid-course guidance system antenna atop the fin. Note also the additional bullet-shaped antenna fairings on the wing leading edge at about half-span and the second cockpit for the engineer operating the guidance system above the wing trailing edge.

Above right: The Tu-4KS prototypes (c/n 224203) carrying two *izdeliye* K missile simulator aircraft; one is the fourth prototype (K-4). Note the cutouts in the missile pylons to accommodate the cockpit canopies.

Right: An interesting aspect of an *izdeliye* K as it falls away from the 'mother ship', showing the attachment lug and the small span and sharp sweep of the wings and stabilisers.

Below right: An *izdeliye* K on the ground. Note the marked nose-up angle and the fairing over the attachment lug. The size of the cockpit gives an idea of how small the aircraft was.



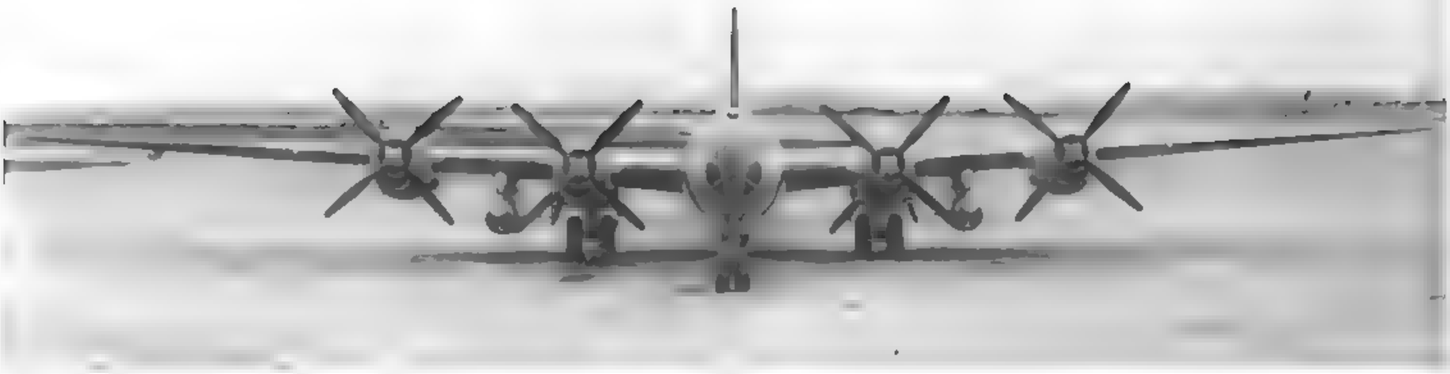
Opposite page: A production-standard KS-1 missile on a ground handling dolly. These views show the cover of the explosive charge compartment replacing the cockpit of the *izdeliye* K aircraft, the pure cigar shape of the fin tip fairing and the shape of the wingtips.

Above and below: A very early example of the KS-1 on a ground handling dolly. Note the air intake splitter, the position of the wing fences, the extra fairing atop the fin tip fairing and the fairings under the wingtips which housed the outrigger landing gear struts on the *izdeliye* K.

concerned lay in the wings which were more sharply swept, with a leading-edge sweep of 57°30', and had 5° anhedral

The MiG-15 style circular nose intake with a vertical splitter was topped by a bulbous radome housing the K-2 terminal guidance (homing) system antenna, the radar set was accommodated in a bay above the inlet duct Further aft were an electric equipment bay and the explosive charge, followed by a bladder-type fuel tank and an APK 5B autopilot located immediately ahead of the engine. The fin was tipped by a rather large cigar-shaped fairing with a dielectric tailcone, this housed components of the mid-course radar guidance system

The KS, alias KS-1 or Kometa, was originally designed with the piston-engined Tupolev Tu-4 bomber (a reverse-engineered version of the Boeing B-29A Superfortress) in mind as a launch platform, the missile-toting version was designated Tu-4K (or



Tu-4KS). The idea is that the bomber's K-1 (*Kobal't-N*) 360° search radar acquires the target in search mode, whereupon the navigator selects tracking mode to generate a high-power directional beam. After launch the KS-1 heads towards the target in level flight, controlled by the autopilot; if the missile departs from the beam the aircraft makes corrective manoeuvres to get the missile back on track. Forty seconds after disengagement the autopilot switches to remote control mode, utilising the triangulation method, and the KS-1 changes its flight path, following the radar beam to the target, the missile's flight level varies at this stage When a certain time has elapsed a timer switches the guidance system to homing mode for terminal guidance. The missile's own K-2 passive radar seeker head then achieves a lock-on, using the echo from the missile platform's radar illuminating the target, and guides the missile all the way to impact. Due to the need to illuminate the target continuously the aircraft was forced to proceed towards the target until the missile hit; yet, in the early 1950s this course of action was deemed to be effective enough

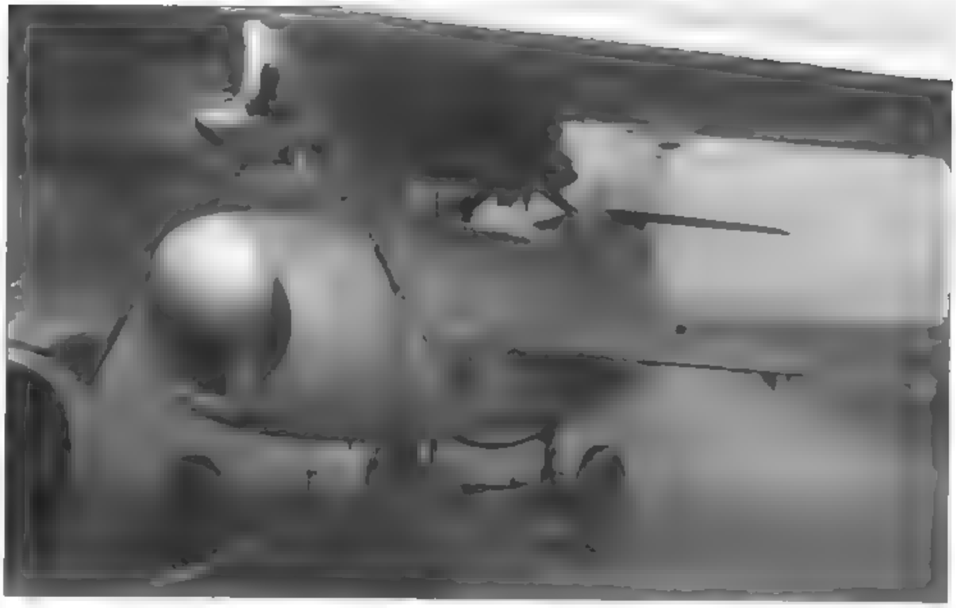
The KS-1's turbojet engine was spun up prior to launch, running on kerosene from a

Above: Front view of a production Tu-4KS (c/n 226305) fully loaded with two KS-1 missiles. Note how the missile pylons are positioned halfway between the inner and outer engines.

Left and below: Live KS-1 missiles hooked up to Tu-4KS aircraft. The shape of the pylons on the prototype (left) and a production aircraft makes an interesting comparison; curiously, the cutout for the simulator aircraft's cockpit is still there.

Right: This is how the KS-1 was hooked up to the BD-187 pylon of the Tu-16KS missile strike aircraft by means of two hand-driven hoists.

Below right and bottom right: KS-1 missiles under the wings of the Tu-16KS prototype; the shape of the KS-1's air intake makes it appear to be grinning saucily. Note the BD-187's retractable retaining arms that keep the missile from rocking from side to side while on the wing.



special tank on the aircraft right up to the moment of separation (the Tu-4's engines ran on petrol, of course). After separation the engine switched to the missile's own tank and accelerated to full military power automatically, retaining this power setting all the way to impact

To speed up the testing of the KS-1 the Mikoyan OKB brought out the *izdeliye* K simulator aircraft, a manned version of the actual missile with a retractable bicycle landing gear, wing flaps and an unpressurised cockpit (equipped with an ejection seat, a set of controls and a very basic instrument fit) instead of the explosive charge. In passing, this was nothing unique. Back in 1945 the German Fieseler company had developed manned versions of the Fi 103 (the famous V-1 'buzz bomb'); but then, unlike *izdeliye* K, these were to be real weapons, not test vehicles

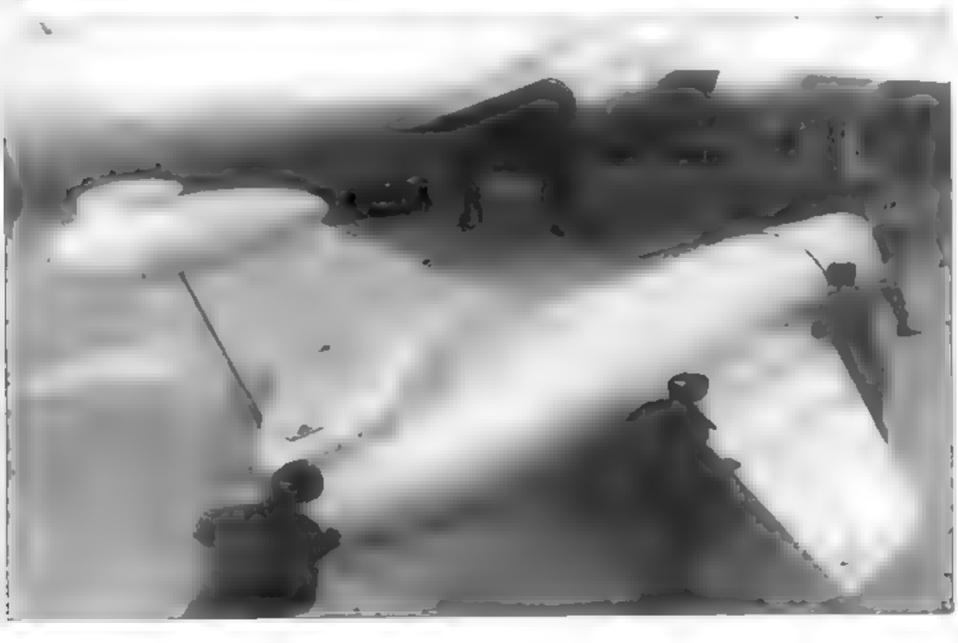
Four prototypes of the simulator aircraft (designated K-1 through K-4) were built. The attachment lug for hooking the missile up to the bomber was immediately aft of the cockpit in the case of the *izdeliye* K, so the missile pylons of the Tu-4KS prototype (no serial, c/n 224203) had to be modified by providing cutouts for the cockpit canopy. As in the case of the real thing, the engine of the *izdeliye* K was started by the crew of the mother ship; unlike the actual missile, however, the aircraft had a regular RD-500 with a normal throttle and fuel control unit instead of the expendable RD-500K (*korotkoresoorsnyy* – with a short service life)

In 1951-52 the Tu-4KS prototype passed manufacturer's flight tests at Chkalovskaya airbase and the Bagerovo test range near Kerch on the Crimea Peninsula, in the course of which the system was brought up to scratch Test pilots Amet-Khan Sultan and Sergey N. Anokhin (some sources say Fyodor I. Boortsev) of the Flight Research Institute named after Mikhail M. Gromov (LII *Lyotno-issledovatel'skiy institoot*) made numerous flights in the *izdeliye* K aircraft which was carried aloft and launched by the Tu-4K, the first such flight was performed by Amet-Khan in the K-1 in May 1951 (some sources say 4th January 1952) Two 'manned missiles' were always carried but only one was launched at any one time. The bomber's propeller discs were uncomfortably close to the cockpit and the pilots were

Above left: Soviet Navy ground crews propel a KS-1 missile towards an operational Tu-16KS coded '52 Blue' The engine nozzle is closed by a cover Note that the missile has that extra fairing on top of the tail.

Left and below left: Heave-ho, Part 2. More Soviet Navy 'black men', this time in winter attire, prepare to hook up a KS-1 to Tu-16KS '24 Red' (c/n 7203818) The additional number 7163 underneath the c/n may signify the 163rd Tu-16 built as a missile carrier Note the clamps securing the missile's control surfaces and the different colour of the nose and tail radomes.

Above: This cutaway KS-1 complete with BD-187 pylon is on display at the Central Russian Air Force Museum in Monino. The antenna dish of the K-2 radar is visible.



reluctant to gun the engine immediately after separation, fearing a collision; as a result, the *izdeliye* K would drop 600-800 m (1,970-2 625 ft) below the bomber's flight path, which made it hard to engage the mid-course guidance beam

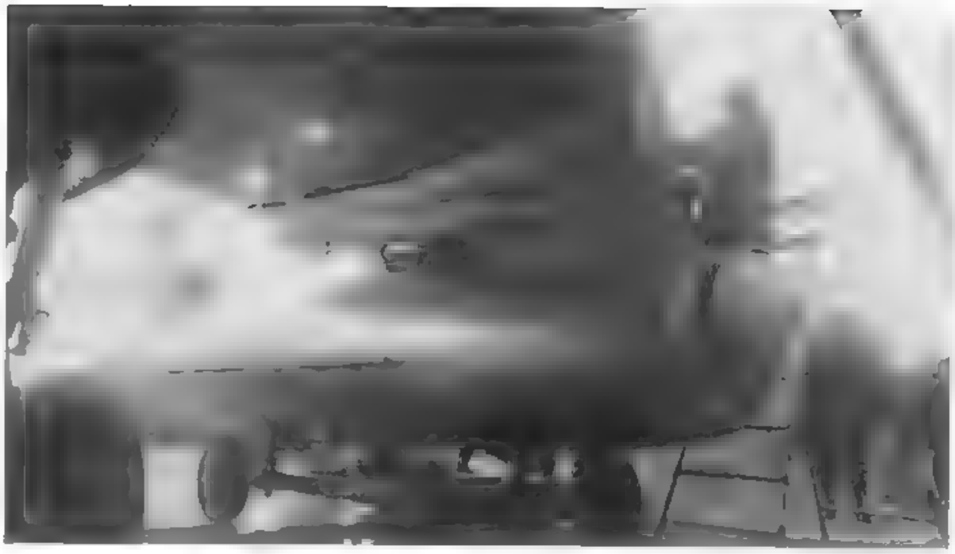
After 150 manned flights had been made, the appropriately modified K-4 commenced a series of unmanned (remote-controlled) launches in May 1952. From this moment on all Soviet air-launched missiles received the K designator at the development stage, although the designation changed after service entry; the next one to receive this designator was the K-5 AAM which became the RS-1-U (see Chapter 1) In the case of the early anti-shipping missiles the K initially still stood for Kometa, most often, however, it denoted ***kompleks*** [*vo'orouzheniya*] · weapons system

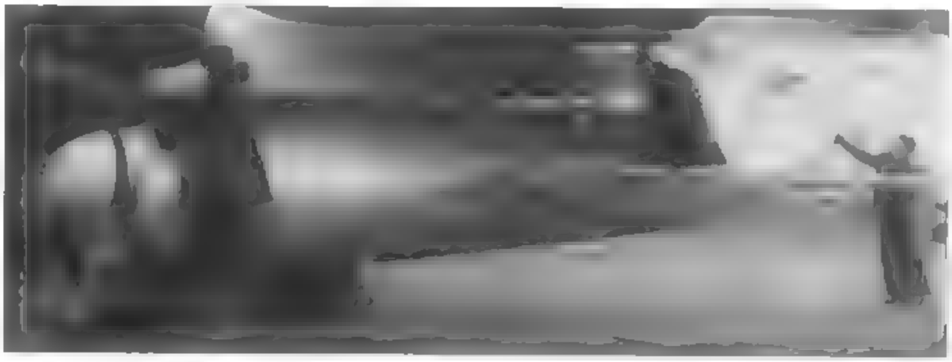
Before the *izdeliye* K 'manned missile' the KS-1's guidance system had been verified on two specially converted Lisunov Li-2 transports, one of which simulated the mis-

Right: The missile is positioned below the port wing pylon and ready for hooking up; the pylon's retaining arms are still retracted, as they are after launch. Note the air intake cover on the upper photo, some missiles had gloss white radomes, others had medium grey ones.

Below right: The final preparations as the KS-1 is hoisted into position and secured.

Bottom right: View from the lateral blister of the ventral gunner/radio operator's station of a Tu-16KS as a sister aircraft unleashes a missile





sile and the other – possibly Soviet Air Force Li-2REO '08 Yellow' (c/n 23440603) – played the part of the 'mother ship' equipped with the target illumination radar. Next, the system was tested on the bizarre MiG-9L (*izdeliye* FK) of 1949 – a much-modified production MiG-9 fighter (*izdeliye* FS) with numerous antennas and a second cockpit for the radar operator – and finally on several MiG-17 fighters converted into MiG-17K (MiG-17SDK, or *izdeliye* SDK-5) missile simulators. The SDK stood for ***samolyot-dooblyor Komety*** – 'doubler aircraft', that is, analogue, of the Comet missile

The first successful launch of a 'real' (production-standard) KS-1 took place on 21st November 1952, and full-scale production at Plant No 207 in Doobna, Moscow Region, started before the year was out. The missile was officially accepted for service in 1953 as part of a weapons system which also included the Tu-4KS, the first of these aircraft (about 50 bombers were converted to this standard by Plant No 22 in Kazan' and Plant No 23 in Moscow) were delivered to the Black Sea Fleet air arm. The Tu-4KS s radar was capable of detecting the target at 250-300 km (155-186 miles), and the missiles could be launched at up to 90 km (56 miles) range, depending on the launch altitude. The Tu-4KS never fired in anger although the Soviet government seriously considered using these aircraft against US Navy aircraft carriers during the Korean War

Yet the Tu-4's obsolescence was obvious even at that stage; a more capable weapons platform was required. Consequently in August 1954 the Tupolev OKB began trials of the first anti-shipping strike version of its latest bomber, the twin-turbojet Tu-16 Designated Tu-16KS and codenamed *Badger-B* by NATO, the aircraft again carried two KS-1 missiles under the wings on BD-187 pylons (BD = ***bahlochnyy derzhatel'*** - beam-type rack). The guidance system was taken straight from the Tu-4KS; the only difference was that the retractable radome of the Kobal't-N search/target illumination radar was boxy, not hemispherical

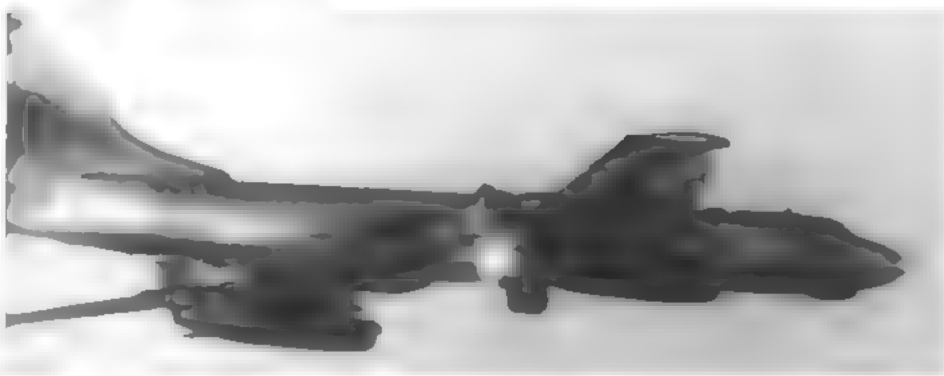
The Tu-16 outperformed the prop-driven Tu-4 considerably, which boosted the combat potential of the weapons system as a whole. Hence the Tu-4KS was progressively

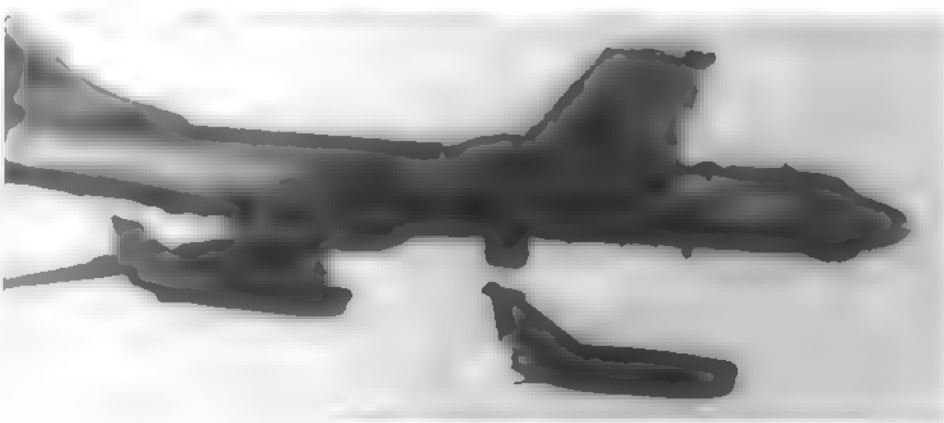
Opposite page. Three views of the uncoded Tu-16KS prototype (c/n 4200305) with two pre-production KS-1 missiles on the pylons. Note the retracted hemispherical radome borrowed straight from the Tu-4KS (its bottom portion is just visible under the centre fuselage) and the forward-hinged main gear door sections found on early-production Tu-16s

Above: A Tu-16KS takes off, carrying a KS-1 painted bright red overall under the port wing The colour indicates this is an inert practice round

Right: The final moments before launch Note the angular shape of the deployed radome of the Kobal't-N radar as fitted to production aircraft. A window and an entry hatch for the radar operator's station can be seen aft of the radome.

Below and bottom right: Stills from a cine film showing how the engine fires up and the KS-1 falls clear of the aircraft before accelerating and heading towards the target.



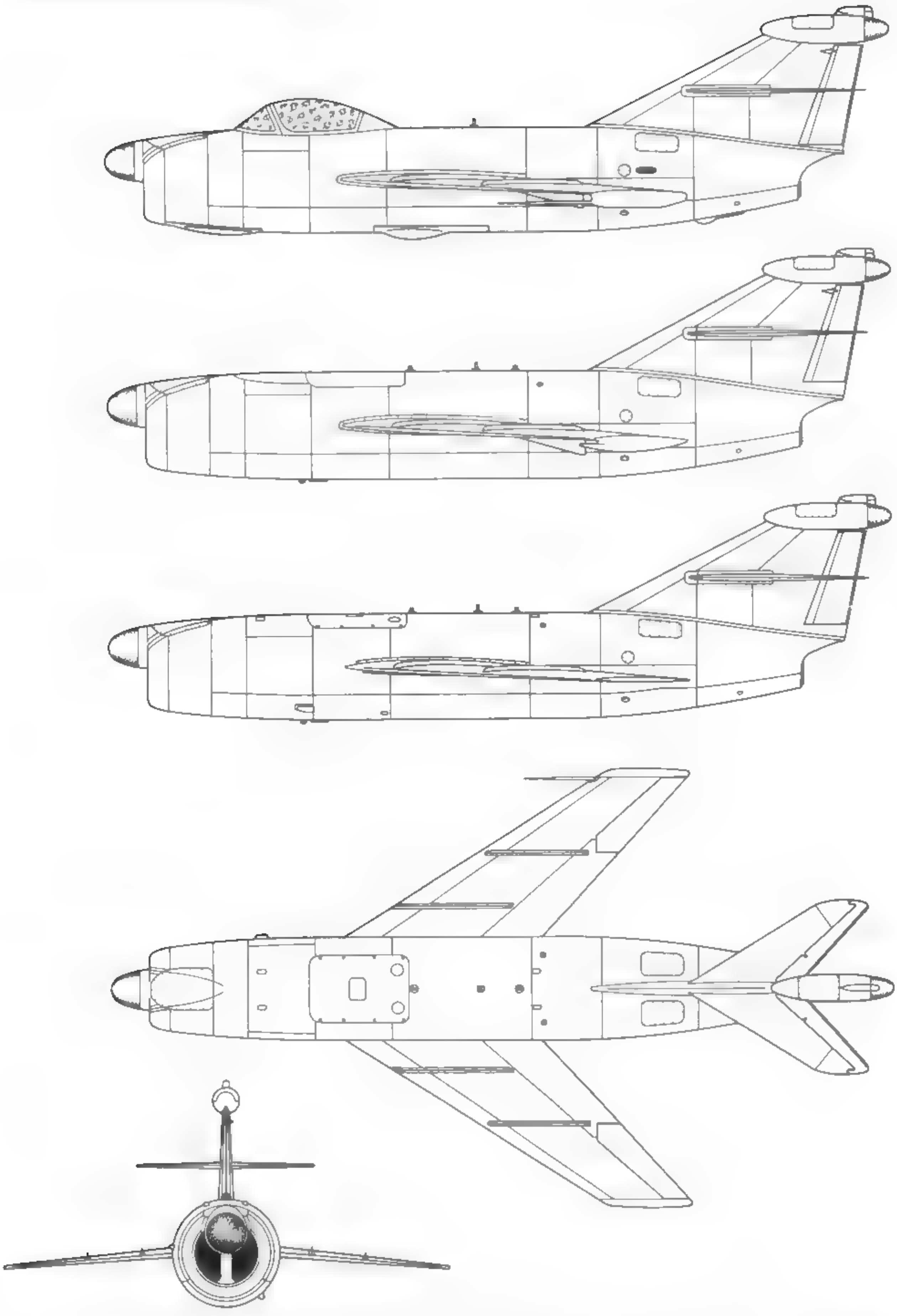


phased out of Soviet Navy service and replaced by the Tu-16KS in the late 1950s, most Tu-4KSs were stripped of their mission equipment and converted to Tu-4D transport/troopship aircraft. The Tu-16KS also saw service outside the USSR. In the early 1960s the Soviet Union donated two squadrons of these aircraft, together with a supply of missiles, to Indonesia which was then ruled by the friendly regime of Dr Soekarno. The other foreign customer was Egypt; about 20 *Badger-Bs* were in service with the Egyptian Air Force at the outbreak of the Six-Day War (5th-11th June 1967), but these aircraft were wiped out on the ground by Israeli air raids in the early hours of the confl ct

Later the already independent Bereznyak OKB created new surface-to-surface versions of the KS-1 – the shipboard KSS – aka *Strela* (Arrow) – and the shore-based S-2 *Sopka* (the name for a high hill in the Far East)

K-10 anti-shipping cruise missile

The bolstering of the potential adversary's sh pboard air defences created the need for more potent offensive weapons, namely



Left, top to bottom: The *izdeliye* K missile simulator aircraft, a pre-production KS-1 and a typical production KS-1

Right. Two Indonesian Air Force Tu-16KSs (with M 1618 foremost) pictured prior to delivery. Note the open radar operator's hatch

supersonic anti-shipping cruise missiles. In 1955 the Soviet aircraft industry started work on the K-10 weapons system comprising a supersonic cruise missile of the same name, the Tu-16K-10 missile strike aircraft and a guidance system based on the YeN twin-antenna airborne target illumination radar. Unlike its predecessors, the Tu-16K-10 carried only a single missile which was semi-recessed in the fuselage while on the ground and en route to the target, being lowered clear of the fuselage by a hydraulically actuated centreline pylon immediately before launch

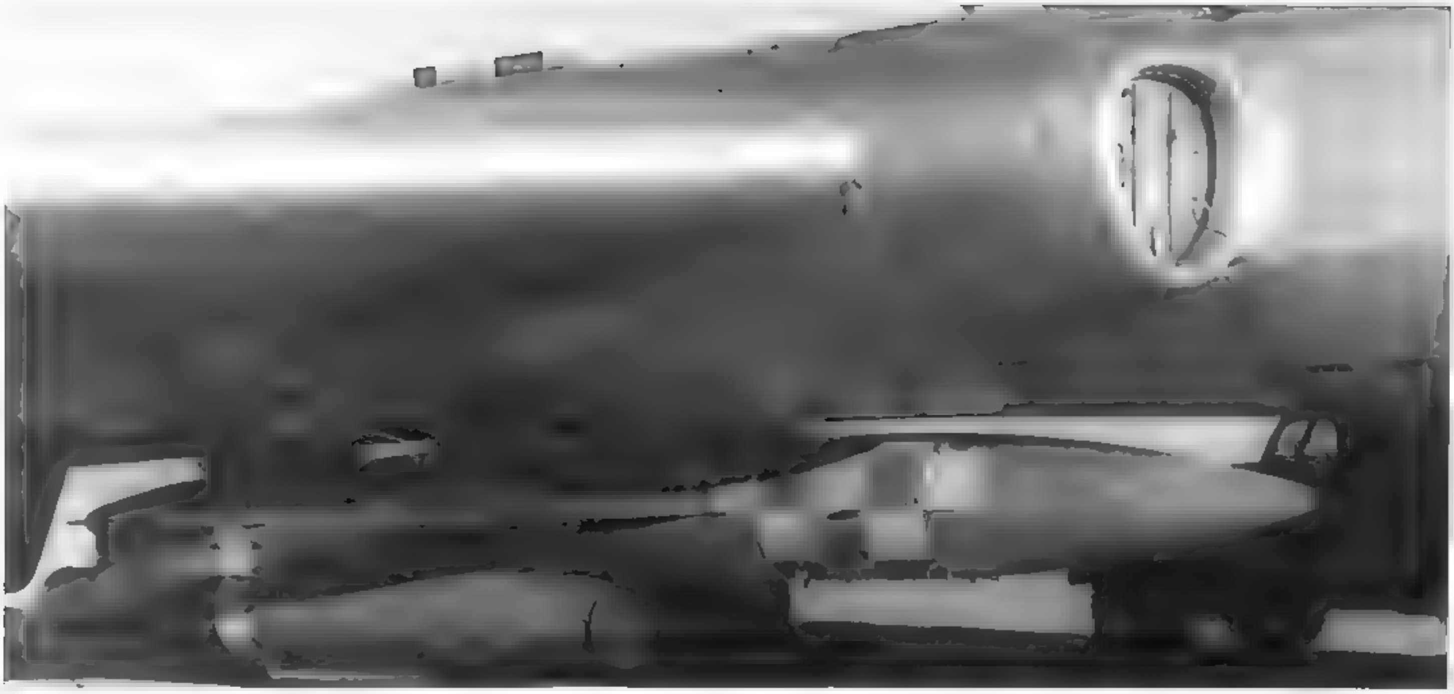
The missile has mid-set wings swept back 55° at quarter-chord that fold upwards vertically for ease of ground handling The tail surfaces consist of slab stabilisers (stabilators) with 55° leading edge sweep and a fin-and-rudder assembly swept back 55°30' at quarter-chord; some examples have a ventral strake as well. The fin can also be folded to facilitate hooking up the missile to the aircraft

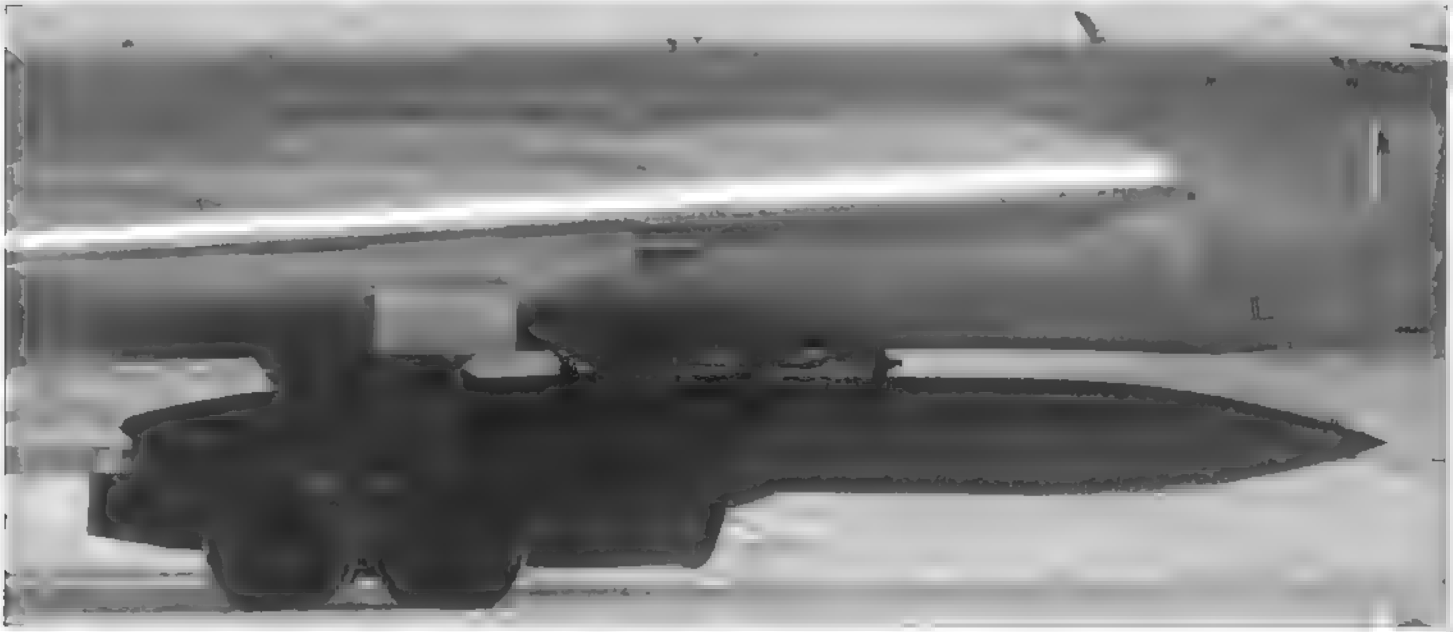
The forward fuselage section terminating in a large ogival radome houses the guidance system. The latter comprises two modules: the first (YeS-2D) is responsible for mid-course guidance, using signals transmitted by the aircraft's YeN radar, and makes altitude corrections, while the second (YeS-1) is an active radar homing and command system used for terminal guidance The missile is also equipped with YeS-3A autopilot (In the designations of the guidance system's components, N stands for *nositel'* – carrier [aircraft] and S for *snaryad* – missile.) The guidance system bay is pressurised and heat-insulated

Section 2 accommodates a shaped-charge/high-explosive warhead, either the FK-1O ('one-o') or FK 1M the latter for striking large naval vessels below the waterline, a nuclear warhead can also be used Section 3, which is the fuel tank, is the main structural element absorbing all the loads and is made of steel A 3,250-kgp (7,160-lbst) Mikulin M-9FK axial-flow afterburning turbojet – a disposable single-mode version of the RD-9B powering the MiG-19 fighter was installed in an underslung nacelle under this section

The K-10 is launched at 11,000 m (36,090 ft) In order to save fuel the engine is started by windmilling after disengagement, the missile losing 800-1,800 m (2,620-5,900 ft) of altitude in the process until the engine achieves full afterburning thrust. Cruise flight takes place at a constant altitude of 9,000-10,000 m (29,530-32,810 ft) after the missile enters the aircraft's radar beam. At a range

A red and white chequered inert K-10 missile on its ground handling dolly. The vertical white stripe on the tail unit and engine nacelle is for photo calibration.



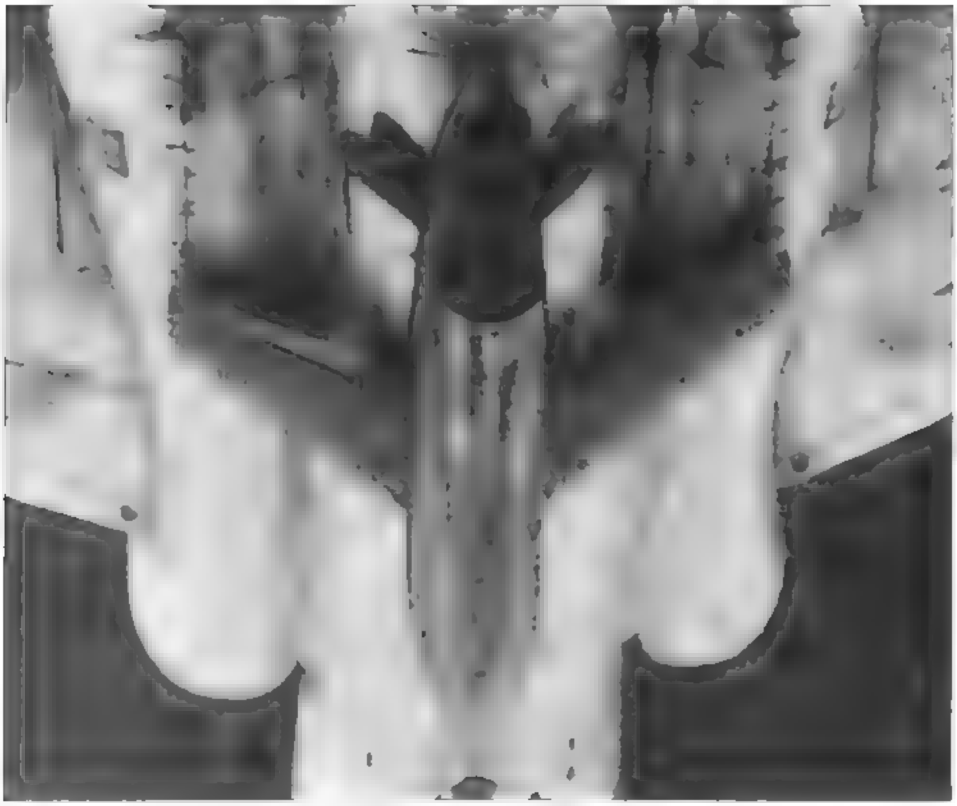


Top: An inert K-10 missile – quite possibly the same one – underneath a Tu-16K-10. The air intake is closed by a cover. The radar operator's station entry hatch is visible aft of the missile

Above: Another K-10 suspended under the first prototype Tu-16K-10. The bottom portion of the centreline missile pylon is visible here.

Left: To facilitate ground handling the K-10S's wings can be folded upwards as shown here. Note the fixed triangular leading edge portions of the wings (the joint line is almost at right angles to the fuselage axis) and the aileron actuator fairings. The Tu-16K-10 in the background carries three mission markers to denote successful practice launches.

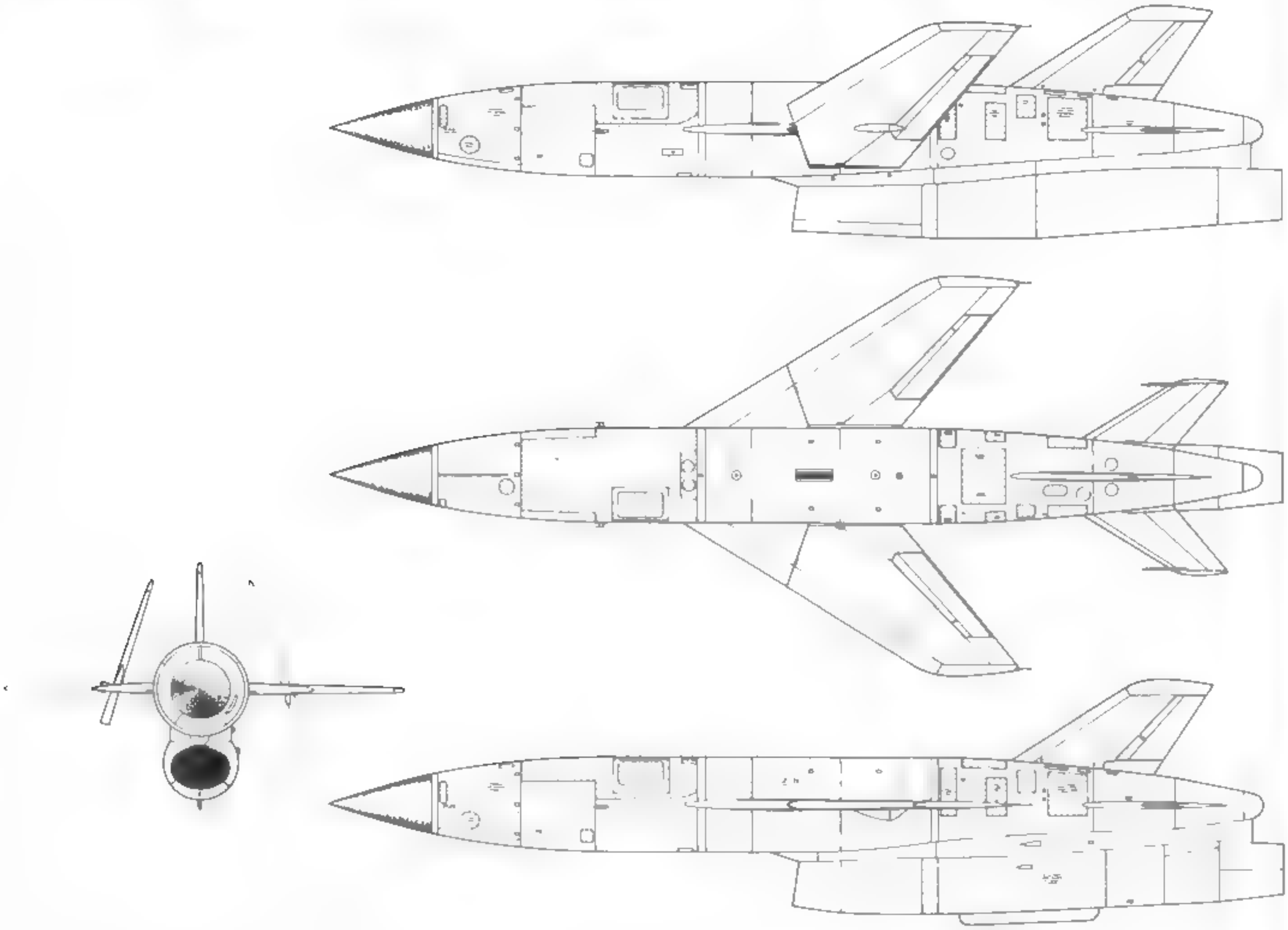
Opposite page. These two views illustrate well the sharply swept wings and tail surfaces, the stabilator anti-flutter booms and the engine nozzle protruding beyond the fuselage tailcone.



of 100-110 km (62-68 miles) from the target it enters a 15° dive, levelling out some 60-70 km (37-43 miles) from the target and again assuming horizontal flight at an altitude of 800-1000 m (2,620-3,280 ft) until some 10 or 16 km (6 2-10 miles) remain; at this point the active radar homing system is activated for terminal guidance At the final stage the missile dives onto the target, impacting at very low level either above or below the target vessel's waterline. The missile's vulnerability to anti-aircraft defences is reduced by its speed, relatively small radar signature and the brief period in which its homing radar can be jammed. After launch the Tu-16K-10 can make an 80° turn away from the target (the missile then follows a horizontally

Left: A semi-recessed K-10S under the belly of a Tu-10K-10 cruising over international waters as seen by the crew of a shadowing NATO fighter. Note the deflected ailerons

Below: A three-view of a production K-10S, with an additional side view (bottom) of the K-10SM low-altitude version. The K-10SM K-10SMB features a shallow strake under the engine nacelle for greater directional stability



Above: The second prototype Tu-16K-10 (c/n 7203806) with a K-10 missile seen during trials. Note the characteristic 'duck bill' radome of the YeN radar and the teardrop fairing supplanting the ventral cannon barbette. It houses test equipment associated with the missile.

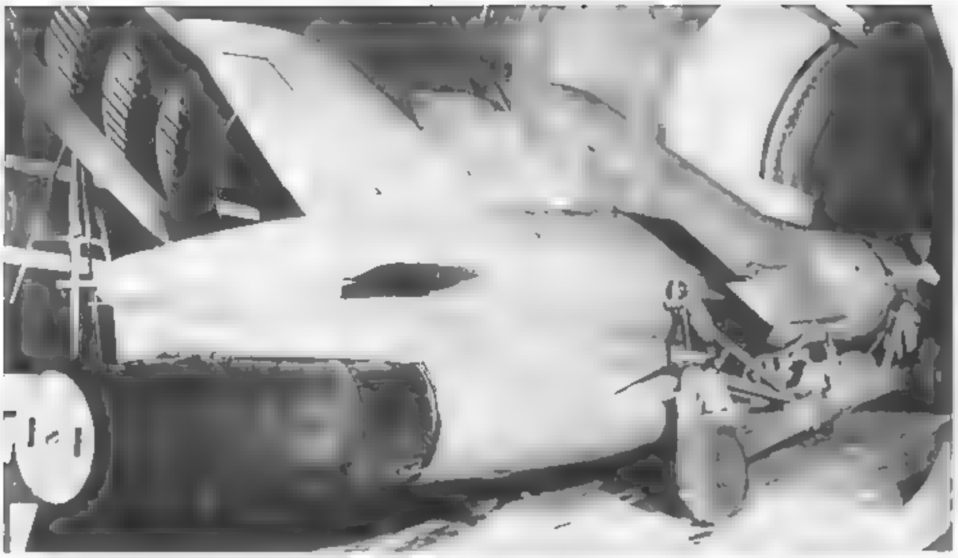
Right: A K-10 is prepared for a mission at the Soviet Air Force Research Institute (GK NII VVS). A power cart and a test equipment van with Soviet Army number plates (62-26 NR) are hooked up to the missile, with a fire engine based on a ZIS-151 6x6 lorry standing by.

Below right and bottom right: A Tu-16K-10 prototype performs a test launch of an inert K-10.

curved flight path); this considerably increased the minimum distance between aircraft and target to 110-150 km (68-93 miles), minimising the risk of coming within range of the enemy air defences.

Flight tests of the Tu-16K-10 and the K-10 missile began in 1958, the weapons system entering service with the Soviet naval air arm in 1961. Almost all production missiles were manufactured with nuclear warheads (this version is designated K-10S, the suffix standing for ***spets**boyepri**pahs*** – 'special munition', as nukes were referred to in the Soviet Union. The K-10S featured additional heat insulation in the warhead bay, since nukes are sensitive to temperature fluctuations. The later K-10SN was designed for low-altitude launches in order to maximise the chances of air defence penetration, as the N suffix (***n**izkovysotnaya* – optimised for low altitudes) shows, a further version designated K-10SNB was optimised for combating 'old ironsides', that is, large ships with armour protection, hence the B (meaning [*dlya porazheniya*] ***b**ronirovannykh* [*korabley*] – for destroying armoured ships).

Later still the K-10 evolved into a pilotless ECM drone version equipped with the *Ryabina* (Rowan) active jammer. It was to be launched by the lead aircraft in a formation to disrupt the operation of a hostile naval group's air defence radars and communica-



A K-10S is wheeled into the full-scale mock-up of the Mil' V-12 heavy-lift helicopter to demonstrate the volume of its cargo hold to the Air Force's mock-up review commission

tions, clearing the way for aircraft toting regular missiles

Kh-20 and Kh-20M cruise missiles

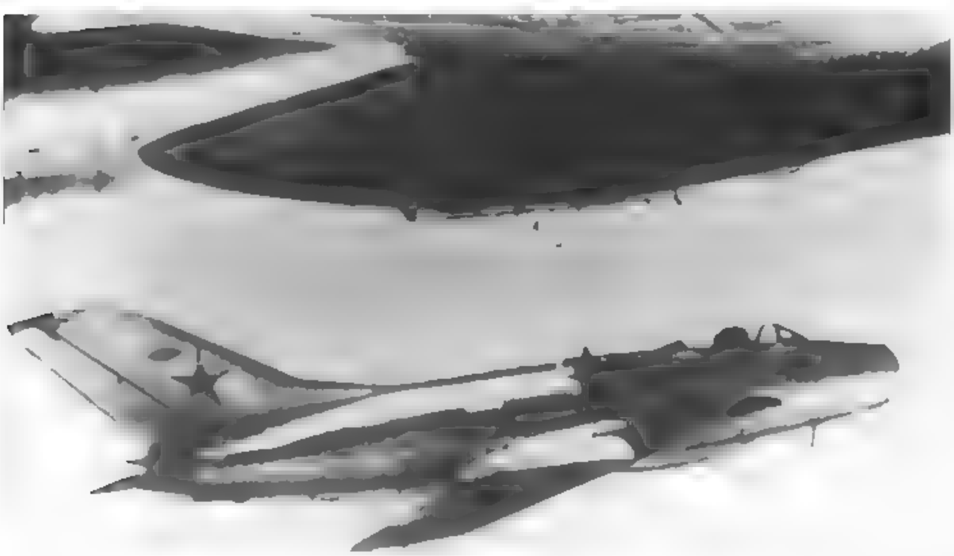
Development of the K-20 strategic missile system proceeded in parallel with the K-10. Unlike the latter, the K-20 was intended for use against stationary or low-mobility targets of strategic importance, such as political and industrial centres, military bases and naval task forces. The system was again a joint effort between Tupolev and Mikoyan, comprising the Tu-95K *Bear-B* missile strike aircraft, the Kh-20 supersonic cruise missile and a guidance system based on the YaD twin-antenna airborne target illumination radar. The meaning of the Kh designator (the 22nd letter of the Russian alphabet), which was used a lot for air-to-surface missiles in subsequent years, remains unknown to this day; on the other hand, the name of the Tu-95K's radar coincides with the Russian word *yad*, 'poison'!

Derived from the airframe of the unsuccessful Mikoyan I-7 interceptor, the Kh-20 has mid-set wings swept back 55° at quarter-chord and swept tail surfaces. The fuselage nose incorporates a sharp-lipped axisymmetrical supersonic air intake with a movable centrebody (shock cone); a pitot boom is mounted underneath. The forward fuselage section houses the No 1 fuel tank.

The centre fuselage section incorporates a heat-insulated bay for the nuclear warhead and its control systems, as well as three more fuel tanks, the AP-YaK autopilot, wing attachment fittings, the engine mount, the lugs for hooking the missile up to the aircraft and so on. An environment control system comprising three electric heaters, a cooling turbine and temperature regulators automatically maintains a temperature of +7 to 17°C (+44 to 62°F) in the warhead bay. The rear portion of the centre fuselage section accommodates the engine; two rectangular engine bleed air outlets are located laterally in this area. The wings are stressed-skin structures with no trailing-edge devices (except ailerons) or boundary layer fences.

The rear fuselage houses the modules of the YaR terminal guidance radar, the control surface actuators, the engine's afterburner and oxygen feed system facilitating start-up at high altitudes and so on. It also carries the tail surfaces consisting of stabilators with anti-flutter booms and a short fin-and-rudder assembly augmented by a ventral strake. The fin terminates in a dielectric tip fairing housing the YaR radar's receiver antenna – possibly the worst possible location for it from an operational standpoint, as the antenna was extremely prone to damage during the loading operation because of the very limited clearance between the fin and the aircraft's belly.

Early production batches (the Kh-20 *sans suffixe*) were powered by the Lyul'ka AL-7F-15 short-life axial-flow turbojet featuring a fixed-area supersonic Laval nozzle



Above left: Despite the high-set all-movable tailplanes *à la* MiG-19S *Farmer-C*, the SM-20/1 guidance system testbed for the Kh-20 missile was a converted MiG-19 *Farmer-A* ('105 Red', c/n 59210105). Note the ventral guidance system housing and the attachment lug aft of the cockpit.

Left: The radio-controlled SM-20/2 (c/n 59210425) falls away from one of the Tu-95K prototypes

The later Kh-20M has an AL-7FK (*korotkoresoorsnyy*) engine with a subsonic fixed-area converging nozzle

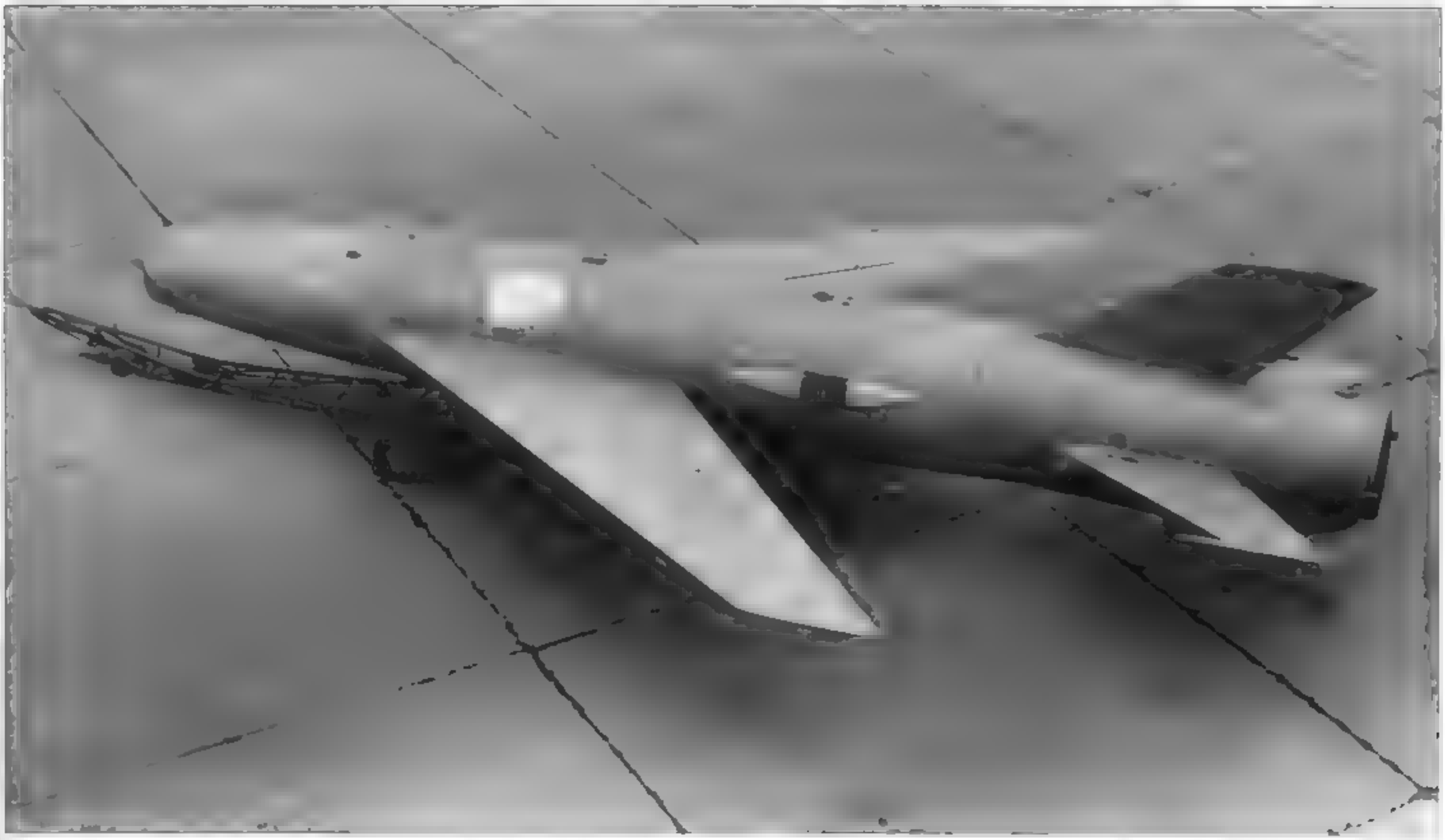
The missile is carried on a BD-206 hydraulically actuated centreline pylon and is semi-recessed in the fuselage at all times except immediately before launch In cruise flight a swivelling parabolic fairing installed immediately ahead of the Tu-95K's weapons bay closes the missile's air intake to stop the engine from windmilling and growing excessively cold, which might impair starting Unlike the K-10, the engine is started after the missile is lowered clear of the fuselage into the slipstream but while it is still on the pylon; to this end an auxiliary kerosene tank is installed in the weapons bay

In common with the preceding Mikoyan missiles the Kh-20 has a combined control system comprising an autonomous control subsystem (that is, autopilot), a radio command directional control subsystem and a subsystem maintaining pre-programmed altitudes at various stages of the flight. The YaR radar receives heading and range information commands transmitted by the Tu-95K

Top. The second prototype Tu-95K (c/n 5800404) seen during trials with a Kh-20 missile semi-recessed in the belly. The 'duck bill' radome was a trademark recognition feature of the Tu-95's missile strike versions.

Above and below right: In cruise configuration the air intake of the semi-recessed Kh-20 was closed by a retractable fairing

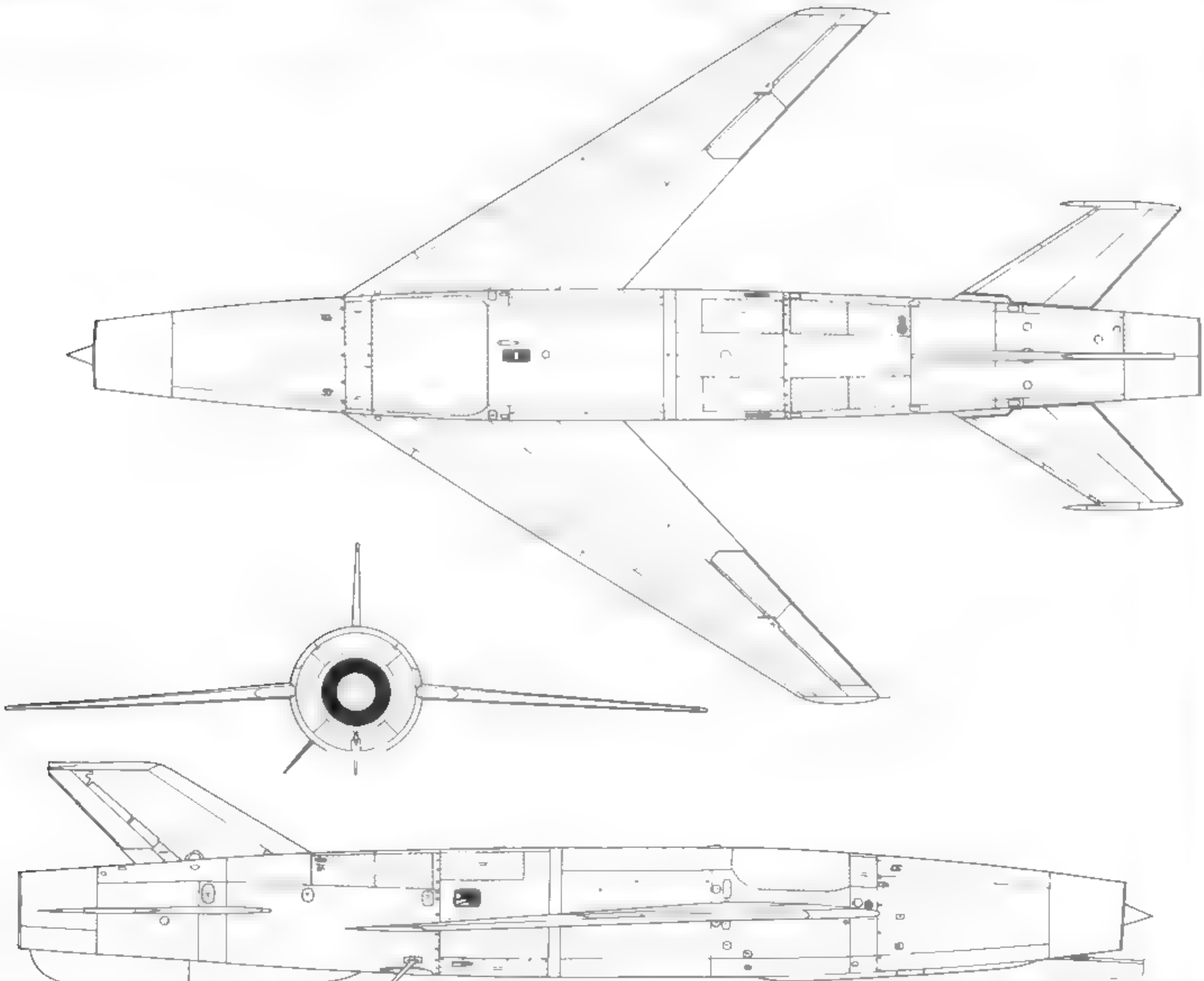
Below: Hooking up the Kh-20 was an arduous procedure The intake cover was for ground handling only.



Above left. This view of a prototype Kh-20 missile illustrates the nose air intake with a movable shock cone and the pitot boom below it.

Centre left and below left. The Kh-20's fin was of necessity shorter than that of the I-7 fighter on which it was based, requiring the addition of a ventral strake to ensure directional stability. Note the massive 12-wheel ground handling dolly and the dielectric portion of the fin which was very prone to damage during loading

Above and below: The production version has faired engine bleed air outlets just aft of the wings. Note the sweep angle of the wings and tail surfaces.



Opposite page top: Front view of the Kh-20, showing the slight wing anhedral
Opposite page bottom: A three-view of the Kh-20.

This page: Two more views of Tu-95K c/n 5800404, showing the bulk of the missile suspended underneath Note the cine camera pod under the starboard wing for recording missile launches during trials; a second camera is fitted in a fairing under the starboard wingtip to capture the separation (see page 89).

Left: A Tu-95K cruises with a Kh-20 missile. The tactical code (in this case, '45 Red') was initially writ large on the aircraft's nose but this practice was soon discontinued for security reasons, the size of the codes being greatly reduced.

Below left: '40 Red', another Tu-95K with an early-style large code. The missile appears to be painted red for greater conspicuity, suggesting this is an airshow appearance in the 1960s.

feeds them to the autopilot and emits signals allowing the aircraft's crew to follow the missile's progress

During the first 270 seconds of flight the Kh-20 is automatically controlled by the autopilot, climbing as it accelerates away from the aircraft. Then the missile enters the aircraft's radar beam and the radio command subsystem takes over. The YaD radar determines the coordinates of both target and missile with respect to the aircraft and generates commands to guide the missile onto a straight line between the aircraft and the target. When this has been accomplished, the missile accelerates to maximum speed in level flight, the flight level is maintained by an on-board system. When the Kh-20 approaches within 75 km (46.5 miles) of the target, the Tu-95K's radar transmits a coded signal switching the missile's guidance system to autonomous mode, whereupon the aircraft can make a U-turn and head for home. When the target is 16.5 km (10.25 miles) away the engine is shut down and the guidance system puts the missile into a 60° dive onto the target.

Two launch modes are possible: radar tracking mode and navigation mode. In the latter case, when there is no radar contact with the target which is beyond the YaD radar's acquisition range, the aircraft's navigator makes the necessary pre-launch calculations to determine the target coordinates and enters them into the range detection module of the missile's YaR radar. Once the Tu-95K is close enough to detect the target with its radar, it provides mid-course guidance to the missile. If the enemy sets up an ECM barrier, the missile's guidance system carries on, using the amended target coordinates.

Depending on the flight level, the YaD radar can detect targets at 390-450 km (240-280 miles) range. Maximum launch range is 450-600 km (280-370 miles) in navigation mode and 370-430 km (230-270 miles) in radar tracking mode, again depending on the altitude. The Kh-20 is launched at any of four prescribed altitudes – 9, 10, 11 or 12 km (29,530, 32,810; 36,090 or 39,370 ft). The minimum launch distance is 150 km (93 miles); in this case the Tu-95K turns back immediately after the launch and there is no mid-course guidance.

The K-20 weapons system joined the Soviet Air Force inventory in 1959. With various updates to the aircraft it remained in service until 1978.

The chief shortcomings common to all turbojet-powered cruise missiles were the considerable launch preparation time (due to the need to crank up the missile's engine and establish operating rpm) and the high weight of the turbojet engine (and hence the missile as a whole). This led all further work on jet-powered air-to-surface missiles to be halted in the 1960s, leaving liquid-propellant rocket motors as the only possible powerplant. It was not until the 1980s that the tables were turned when compact and efficient disposable turbofan engines for cruise missiles became available.

The following table gives the specifications of the Mikoyan OKB's cruise missiles.

	KS-1	K-10S	Kh-20M
Codename:			
US	AS-1	AS-2	AS-3
NATO (ASCC)	*Kennel*	*Kipper*	*Kangaroo*
Service entry	1953	1961	1959
Length overall	8.29 m (27 ft 2⅜ in)	9.75 m (31 ft 11⅞ in)	14.603 m (47 ft 10 57/64 in)*
Wing span	4.722 m (15 ft 5 29/32 in)	4.18 m (13 ft 8 9/16 in)	9.03 m (29 ft 7½ in)
Wing sweep at quarter-chord	55°	55°	55°
Fuselage diameter	1.145 m (3 ft 9 in)	1.0 m (3 ft 3⅜ in)	1.705 m (5 ft 7⅛ in)
Launch weight, kg (lb)	2,735 (6,030)	4,533 (9,993)	11,660 (25,705)
Warhead weight, kg (lb)	800 (1,760)	940 (2,070)	2,566 (5,656)
Launch range, km (miles)	80 (50)	110-325 (68-200)	150-600 (93-370)
Launch altitude, m (ft)	Up to 4,000 (13,120)	1,500-11,000 (4,920-36,090)	9,000-12,000 (29,530-39,370)
Flight altitude, m (ft)	400 (1,310)	500-8,000 (1,640-26,250)	15,000 (49,210)
Speed, km/h (mph)	1,060 (658)	2,030 (1,260)	2,200 (1,366)
Powerplant	Klimov RD-500K	Mikulin M-9FK	Lyul'ka AL-7FK
Missile platform	Tu-16KS Tu-4KS	Tu-16K-10 Tu-16K-10-26	Tu-95K Tu-95KD Tu-95KM

* Less pitot boom; overall length including the pitot is 15.415 m (50 ft 6 57/64 in)

Bereznyak's Cruise Missiles (MKB Raduga)

As already mentioned, until 1967 the design bureau of Aleksandr Yakovlevich Bereznyak existed as a section of Mikoyan's OKB-155, residing in Doobna at the premises previously occupied by the 'German' OKB-2 whose captive staff had returned home to Germany. In 1967 it became organisationally separate, and in this capacity as an independent enterprise named MKB Raduga ('Rainbow' Machinery Design Bureau) it created virtually all of the air-launched cruise missiles that saw service with the Soviet Air Force and Naval Air Arm, as well as many ground-launched and sea-launched (anti-shipping) cruise missiles. At the time of writing the company is headed by General Designer I. S. Seleznyov.

KSR-2 and KSR-2M cruise missiles; KRM-2 target drone

Developed in 1958 as a successor to the far-from-perfect KS-1, the KSR-2 was the Soviet Union's first production cruise missile with a liquid-propellant rocket motor.

The KSR-2 is similar in structure and layout to the K-10, but the provision of liquid-propellant rocket motor has cut structural weight and simplified operational use. Unfortunately the latter does not apply to ground handling and maintenance procedures; the greatest inconveniences are caused by the use of use of corrosive and highly toxic propellant components – TG-02 hypergolic (that is, self-igniting) fuel (called TT-S2 in some documents) and AK-20F oxidiser. An S2.721V two-mode rocket motor with twin combustion chambers designed by Aleksey M. Isayev is located in the missile's rear fuselage. It fires automatically at the moment of release, operating initially in boost mode with a thrust rating of 1,200 kgp (2,645 lbst), once the missile has turned on to the target heading, one of the chambers shuts down and the motor switches to the more fuel-efficient cruise mode, delivering 700 kgp (1,540 lbst).

The KSR-2 has mid-set swept wings with two boundary layer fences on each side and

A red/white chequered prototype KSR-2 missile under the port wing of a Tu-16KSR-2 missile strike aircraft.


49

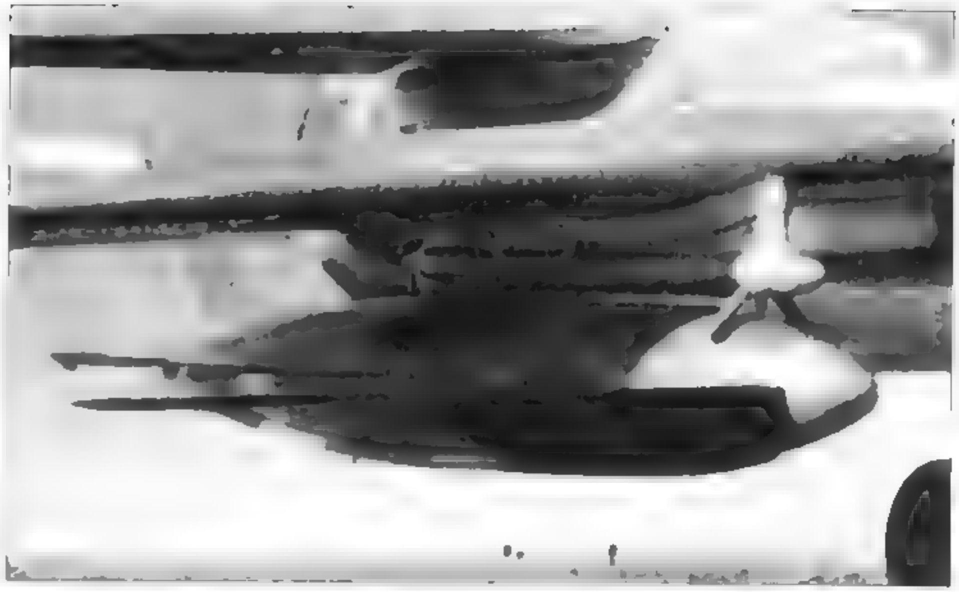

49

Left: A KSR-2 missile on a ground handling dolly. This view illustrates the clean contours of the missile and the very neat fin tip pod for the mid-course guidance antenna.

Below left and bottom left: the Tu-16KSR-2 prototype, '49 Red' (c/n 7203608) with the additional tail number 7124 (that is, 124th missile carrier Tu-16?) and photo calibration markings on the nose, is seen here with a pair of KSR-2s.

Right: Close-up of a KSR-2 on a BD-352 pylon. Part of the belly appears to be painted black.

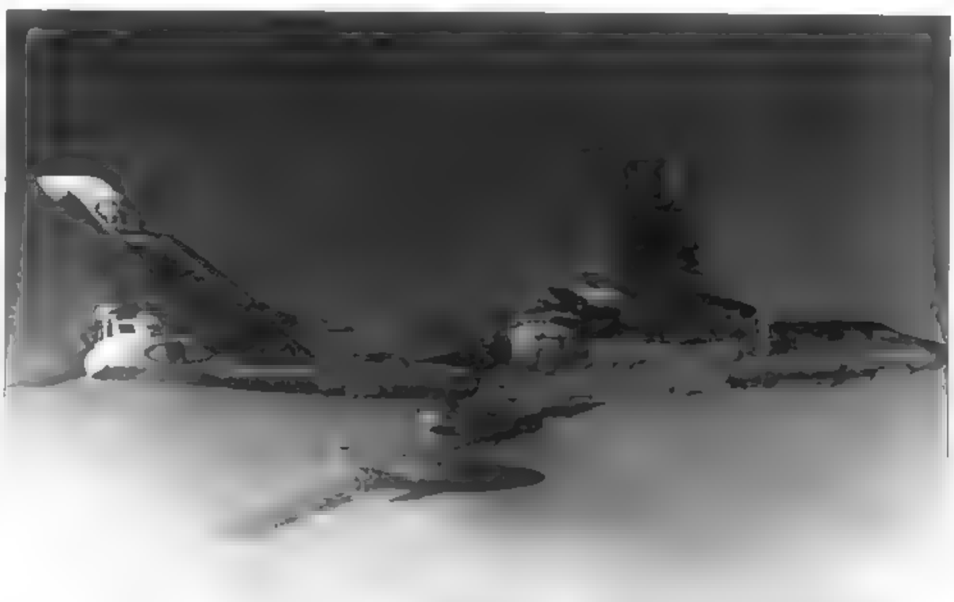
Below right: Another KSR-2 on the wing. Note the large radome and the ventral piping conduit.



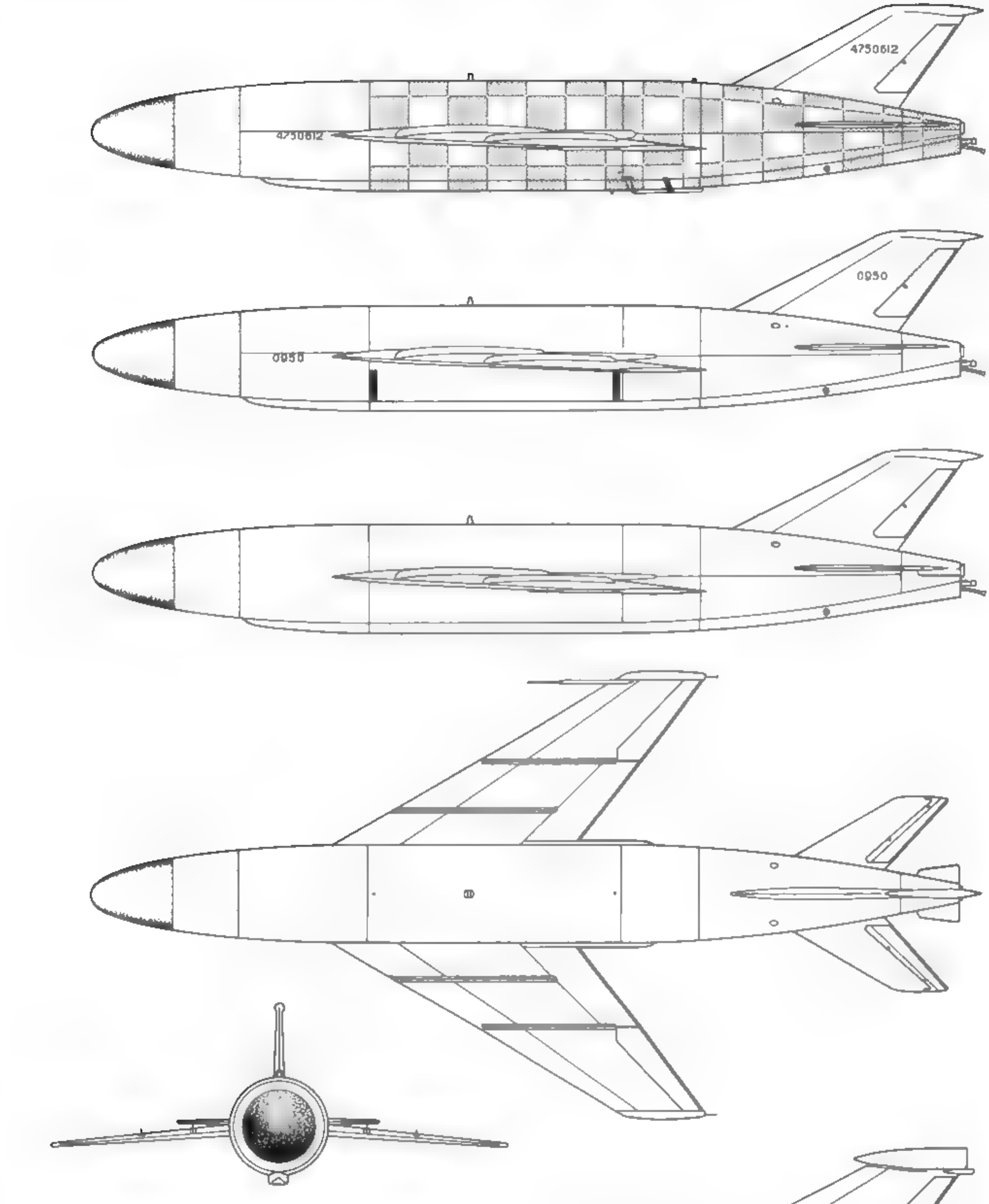
5° anhedral. The conventional swept tail surfaces feature inset control surfaces, vertical and horizontal tail sweep at quarter-chord is 62° and 55° respectively. A high-explosive warhead is normally fitted, but provision is made for a nuclear warhead. The control and guidance systems are similar to those of the KS-1

Flight tests of the K-16 weapons system comprising the Tu-16KSR-2 missile strike aircraft equipped with the new *Roobin-1K* (Ruby) search/target illumination radar and two KSR-2 missiles carried under the wings on BD-352 pylons began in 1958. The prototype was converted from a production Tu-16KS ('49 Red', c/n 7203608). In the course of the trials live missiles were launched both at decommissioned ships and at ground targets. The radar's maximum target acquisition range was 200 km (124 miles). One or two KSR-2s could be carried and launched either simultaneously or individually. Preparations for launch were the responsibility of the navigator sitting in the nose, the automated processes carried out by the Roobin-1K system making the provision of a radar operator sitting amidships (as on the Tu-16KS) unnecessary

In 1962 the K-16 weapons system was brought into the Soviet Navy inventory. Apart from the Soviet Union, Egypt also purchased a number of Tu-16KSR-2s, putting them into action against Israel during the Yom Kippur War in October 1973. Subsequently the KSR-2 missile and its updated version, the KSR-2M, saw service with the Soviet Navy as part of more modern weapons systems based on the Tu-16K-11-16, Tu-16KSR-2-5 and other aircraft. The KSR-2M incorporated some features of the then brand-new KSR-5 missile, such as the new Isayev S5 6.0000 rocket motor; as a result, the minimum launch altitude was reduced from 1,500 to 500 m (from 4,920 to 1,640 ft). The upgraded K-16 weapons sys-



A fine view of an operational Tu-16KSR-2 carrying a full weapons load. Note the cutouts in the outer flap sections preventing the flaps from striking the missiles' fins when fully deployed.



Top to bottom. A development example of the KSR-2 anti-shipping missile; a production KSR-2 (the upper and front views also show this version); the KSR-11 anti-radiation missile with pitots on both wings; and the KRM-2 (MV-1) target drone.

Right and below right: A KSR-2 is prepared for hooking up to a Tu-16KSR-2. Production missiles were light grey overall, except the darker radome. The photos were taken during a chemical warfare exercise, as the ground personnel are wearing gas masks.

tem featuring KSR 2M missiles entered service in 1967.

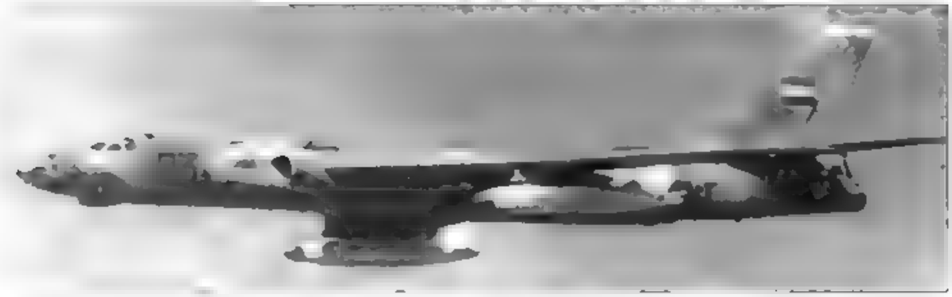
Another derivative which entered service a year earlier (in 1966) was the KRM-2 remote-controlled target drone (KRM = *krylataya raketa-mishen'* – cruise missile/target drone); also known as the MV-1 (probably *mishen' vysotnaya* – high-altitude target drone), it was intended for training the units of the nation's Air Defence Force (PVO – *Protivovozdooshnaya oborona*). The KRM-2 differs from the live version in having an altered nose lacking the guidance system radome, a different rear fuselage housing a new R209-300 liquid-propellant rocket motor, additional arrowhead-shaped vertical fins and a large fin top fairing. The drone has a maximum range of 376 km (233.5 miles). Top speed at 22,500 m (73,820 ft) is 2,760 km/h (1,714 mph); the maximum flight altitude is 25,000 m (82,020 ft) and the duration of level flight is 433 seconds. Tu-16KRM drone launcher aircraft converted from surplus Tu-16KSR-2s and other versions of the *Badger* served as the launch platforms.

KSR-11 anti-radiation missile

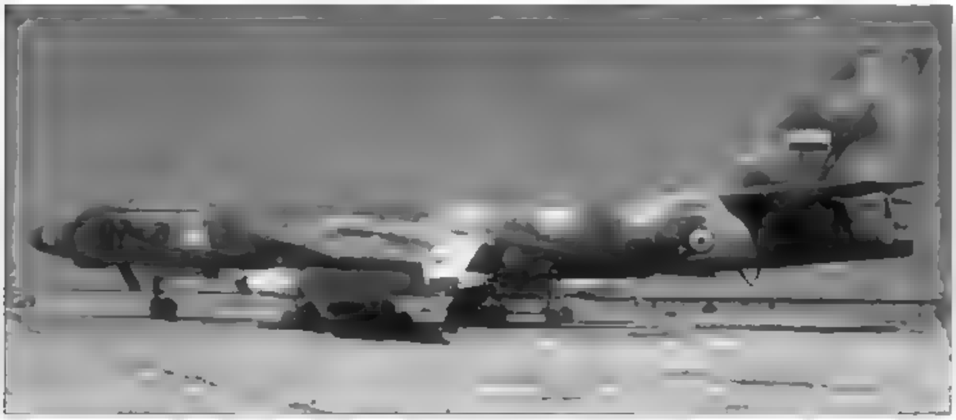
Looking almost identical to the KSR-2M and being very similar to it structurally, the KSR-11 differs only in equipment. Unlike the baseline model, which is fairly versatile, this is a specialised weapon – an anti-radiation missile (ARM) designed for destroying enemy air defence radars, ECM facilities and the like by homing in on their signal. The KSR-11's guidance system comprises a 2PRG-11 passive radar seeker head (PRG = *passivnaya rahdiolokatsionnaya golovka [samonavedeniya]*) and an autopilot, hence there is no need for continuous target illumination and the aircraft can return to base immediately after launching the missile.

The ARM is part of several weapons systems based on the Tu-16. In order to use this missile the aircraft needs to be fitted with the Ritsa radar detection/target indication system (named after a famous picturesque lake in Abkhazia): *Badgers* thus equipped are easily identifiable by an inverted T-shaped direction-finder antenna on the extreme nose (on the navigator's station glazing frame). Unlike the KSR-2/KSR-2M, which can carry a nuclear charge, the KSR-11 fea-

Since the KSR-2 can carry a nuclear charge, this Tu-16KSR-2 has undersurfaces painted gloss white as a measure of protection from the flash of a nuclear explosion.



Left: A number of Tu-16KSR-2s was supplied to Egypt. This example is serialled 4403 in Arabic numerals but also carries the code '03 Black'.



Below left: Egyptian Air Force Tu-16KSR-2-11 '4404'/'07 Black' (note the Ritsa array on the nose) with two white-painted KSR-2s.
Via Aerospace Publishing

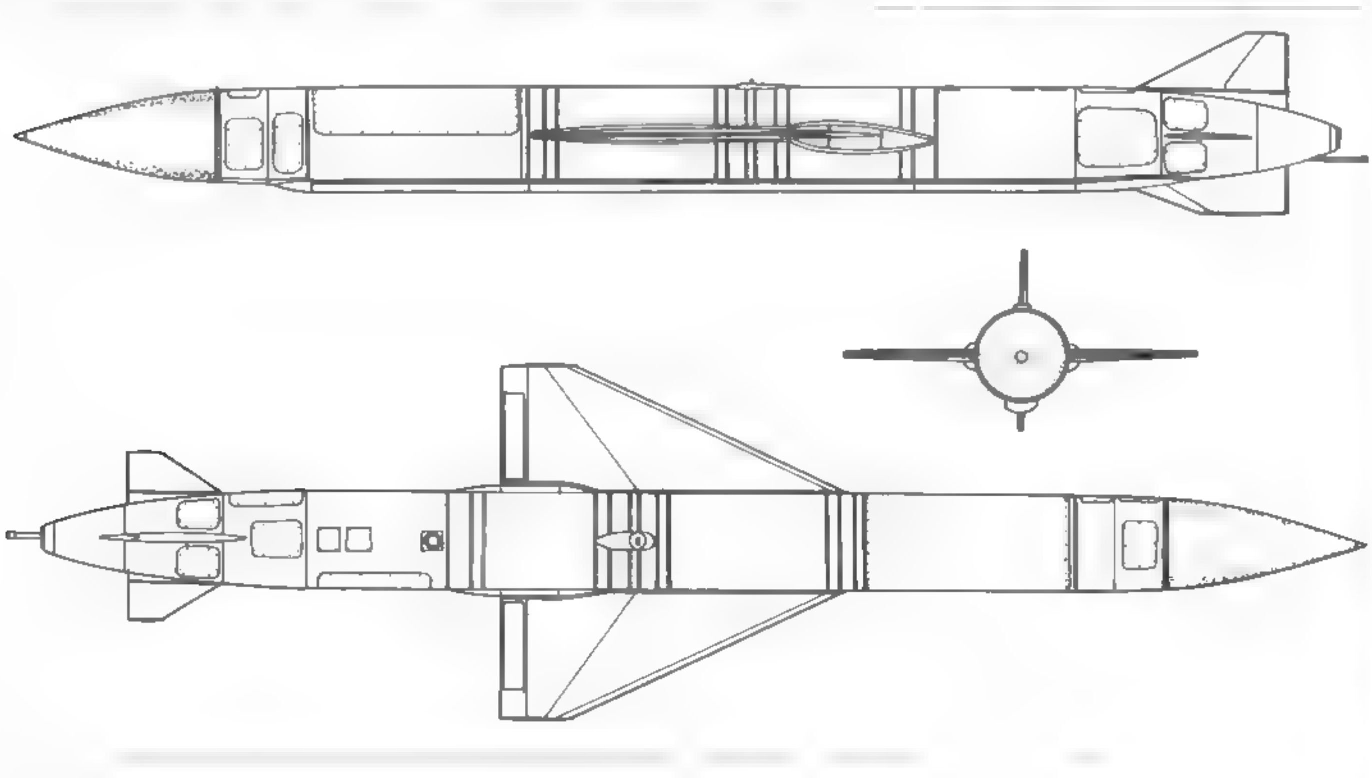
tures strictly a high-explosive warhead only. The Tu-16K-11-16 and other compatible versions can tote a mix of KSR-11s and ordinary missiles – that is, one of each kind

K-12 cruise missile

Developed as a follow-on to the KSR-2, K-10 and other supersonic cruise missiles of the day, the K-12 was intended for use against heavily armoured ships, ground targets with a high radar signature and the like. In the late 1950s it became part of a unique weapons system – the K-12B consisting of the Beriyev Be-10N flying boat (a missile-armed version of the world's first production jet-powered flying boat, hence the N for *nositel'* – [missile] carrier or delivery vehicle), two K-12B missiles suspended on pylons under the wing roots and the K-12U guidance system. The guidance system utilised the active radar homing principle, the targets being detected and selected by means of the aircraft's Shpil' (Spire) radar housed in a bulbous radome supplanting the usual navigator's station glazing. The missile was equipped with a KN active radar seeker head and an AP-72-12 autopilot.

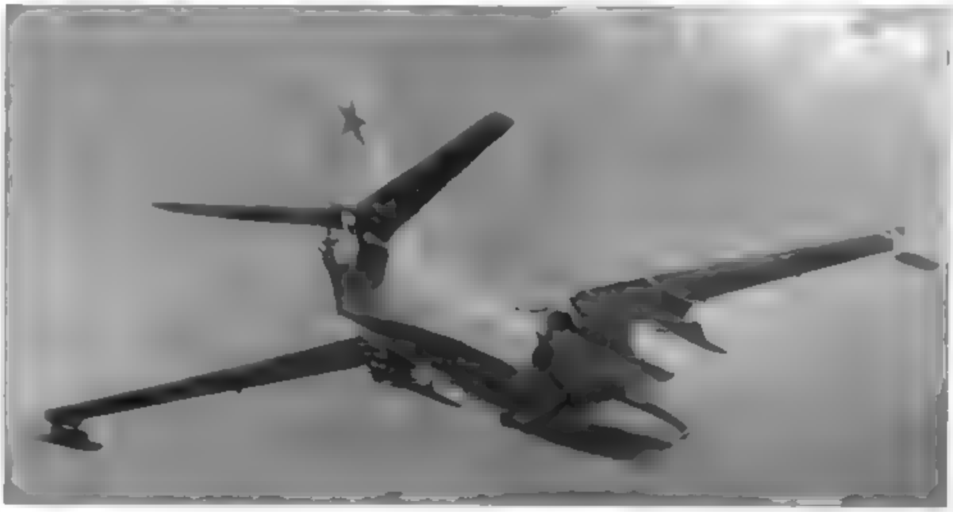
The K-12 was similar in appearance and layout to the later Kh-22 and KSR-5 missiles described below. It had delta wings and slab stabilisers (stabilators); the trapezoidal vertical tail consisted of a fixed ventral portion and an all-movable dorsal portion The rear fuselage housed an Isayev S2 722V liquid-propellant rocket motor with turbine pumps delivering the fuel and oxidiser After launch it ran at a 1,200-kgp (2,645-lbst) initial rating for 120 seconds then switched to a cruise rating of 550 kgp (1,210 lbst) for another 150 seconds

With a single missile the Be-10N's combat radius was 1,250 km (776 miles), increasing to 2,060 km (1,279 miles) if the seaplane alighted once en route to top up its fuel tanks from a submarine. This allowed the Be-10N to attack targets in the middle of the Atlantic Ocean or the Pacific. The Shpil' radar had a target acquisition range of 150 km (93 miles) against surface ships. The K-12B missile could be fitted with a conventional warhead or a nuclear one (the latter



A three-view of the K-12BS missile. Note that the upper fin is all-movable while the lower one is fixed.

Right and below right: Artist's impressions of how the Be-10N missile strike flying boat would have looked These views show well the bulbous radome of the Shpil' target illumination/guidance radar and the two K-12BS missiles on pylons at the inner/outer wing joints.



variety was designated K-12BS) When the missile tore through the ship's side at an angle between 45° and 90°, the fuse detonated the conventional charge inside the ship for maximum damage; if the impact angle was less than 45° (a glancing blow), the charge was detonated immediately to prevent a ricochet.

The K-12BS missile and the K-12B weapons system as a whole underwent manufacturer's tests but were not cleared for production because of changing priorities – flying boats were already considered obsolete, regardless of powerplant type.

Kh-22 cruise missile

No sooner had the '105A' (Tu-105A) twin-turbojet supersonic bomber entered production and service as the Tu-22 *Blinder-A* than the Tupolev OKB began development of a missile strike version designated Tu-22K (NATO reporting name *Blinder-B*) This aircraft formed the core of the K-22 weapons system which also included the Kh-22 anti-shipping cruise missile and associated guidance equipment. Development of the Kh-22 was initiated by a Council of Ministers directive dated 17th June 1958

The following tables give the specifications of the Bereznyak OKB's cruise missiles.

	KSR-2	KSR-11	K-12BS
Codename			
US	AS 5A	AS 5B	none
NATO (ASCC)	*Kelt*	*Kelt*	none
Service entry	1962	1969	Prototypes only
Length overall	8.647 m (28 ft 4 7/16 in)	8 647 m (28 ft 4 7/16 in)	8 36 m (27 ft 5¼ in)
Wing span	4.522 m (14 ft 10 in)	4.522 m (14 ft 10 in)	2 25 m (7 ft 4 19/32 in)
Wing sweep at quarter-chord	55°	55	65°
Fuselage diameter	1.0 m (3 ft 3⅜ in)	1 0 m (3 ft 3⅜ in)	n a
Launch weight, kg (lb)	4,077 (8,988)	3 983 (8,780)	n a
Warhead weight, kg (lb)	750 (1,650)	750 (1,650)	350 (770)
Launch range, km (miles)	160 (99)	170 (105)	110 (68)
Launch altitude, m (ft)	4,000-10,000 (13,120-32 810)	500-10,000 (1,640-32,810)	5,000-12 000 (1 640-39,370)
Flight altitude m (ft)	– (dive)	9 700 (31,820)	5,000-12 000 (1.640-39,370)
Speed, km/h (mph)	1,250 (776)	1,250 (776)	2 500 (1,552)
Powerplant	Isayev S2 721V	Isayev S5 6 0000	Isayev S2 722 V
Missile platform	Tu-16KSR-2 Tu-16K 11-16 Tu 16KSR 2-5 Tu-16K 26	Tu-16K-26 Tu-16K-11-16	Be-10N

The first prototype of the Tu-22K missile strike aircraft ('24 Black', c/n 5060045) with a red-painted inert Kh-22 missile semi-recessed in the fuselage.

The Kh-22 is basically a scaled-up version of the ill-starred K-12 Two versions were developed in parallel. The first one was designed for destroying single targets with a high radar signature, such as solitary ships, it has a PG active radar seeker head which locks on to the target while the missile is still on the pylon. Version 1 has two optional warheads – a shaped-charge high-explosive/ armour-piercing warhead (version BN) and a nuclear warhead (version B) The conventional warhead has an impact fuse, while the nuclear one is detonated by the guidance system at a preset distance from the target

The other version, available only with a nuclear warhead, is intended for use against large-area targets (groups of ships or large ground targets), it features a self-contained three-beam Doppler dead reckoning system designated PSI Hence the two versions are sometimes referred to as the Kh-22PG and Kh-22PSI respectively. It is easy to discern between them, the Kh-22PG has a conventional (and quite large) ogival radome, whereas the Kh-22PSI features an identically shaped metal nose with a ventral dielectric panel of rectangular planform

The Kh-22 is carried semi-recessed in the Tu-22K's belly on a BD-294F hydraulically powered pylon and launched at an altitude of 10,000-14,000 m (32,810-45,930 ft) Three seconds after release the liquid-propellant rocket motor fires, accelerating the missile to Mach 3.4: ten seconds after release the autopilot initiates a programmed climb until the Kh-22 reaches 22 500 m (73,820 ft) and cruises on at this altitude Once the speed of Mach 3.4 had been attained the larger of the two combustion chambers (the booster chamber) shuts down and the motor operates in cruise mode Twenty-five seconds after launch the missile's homing system is activated. The APK-22A electric autopilot stabilises the missile around its centre of gravity, altitude stabilisation is performed by an altitude correction module which is part of the autopilot

The radar seeker head tracks the target in two planes, generating commands which are fed into the autopilot. Once a preset vertical angle between the seeker head's radar beam and the direction of flight is reached, the autopilot shuts down the rocket motor and puts the Kh-22 into a 30° dive towards the target. The missile remains fully controllable at this stage, guidance commands being generated by the seeker head

The Kh-22PG turned out to be quite a potent anti-ship weapon even when a conventional warhead was fitted Trials showed that a single direct hit could tear a gaping 20 m² (215 sq ft) hole in a ship's side and the

A Tu-22KD equipped with an in-flight refuelling probe flies over international waters, carrying a live Kh-22 with a silver-painted body. Note that the missile's ventral fin is folded (compare with the photo at the top of the page)

Right. Front view of a Tu-95K-22 with two Kh-22M missiles under the wing roots. The missile pylons are located extremely close to the fuselage and hence are quite long to provide adequate clearance for the missiles' wings. Note the nose-up angle of the missiles when on the wing and the ventral fins folded to starboard

Below right: Close-up of the Kh-22Ms, showing the radomes of the PMG radar seeker heads.

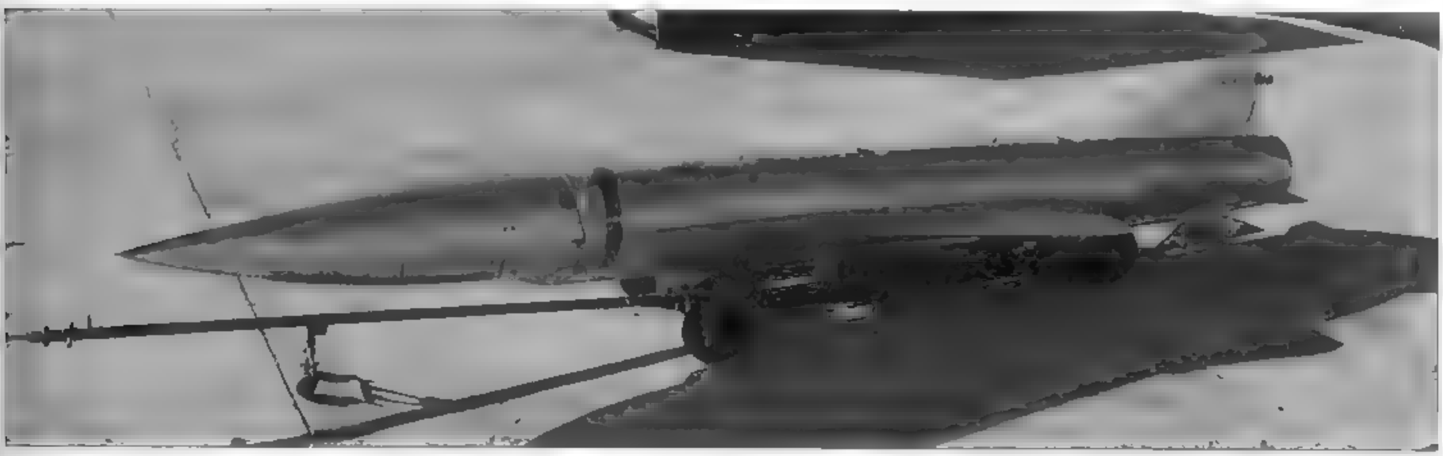
shaped charge could burn its way up to 12 m (40 ft) into the ship's innards

When the objective is a large target and the Kh-22PSI version is carried, the Tu-22K's crew ascertains the target co-ordinates, using the PN radar and other navigation systems. The missile's guidance system emits a radar signal with a specific frequency in the direction of the target and picks up the echo Using this echo, the missile's data processor constantly computes the true speed and remaining distance to the target, initiating a 30° dive at the right moment. Tests showed that the missile's accuracy margin was 5 km (3 miles)

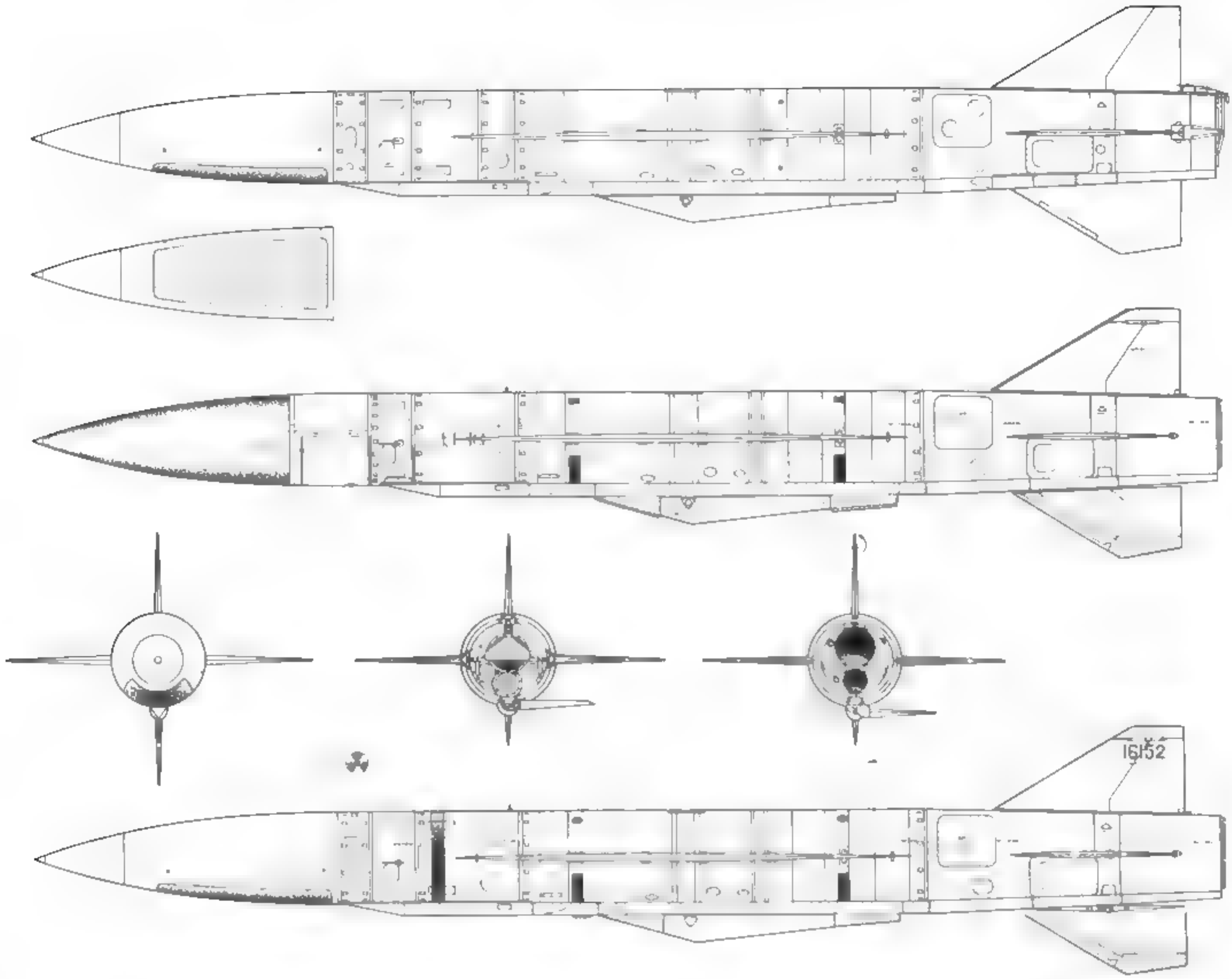
The Kh-22's airframe is constructed of titanium alloys and stainless steel. For ease of maintenance the fuselage is built in several sections joined by flanges, with detachable access panels facilitating conversion from one variant into another The forward fuselage section accommodates the control and guidance system modules and the warhead. The centre fuselage consists of fuel and oxidiser tanks welded together into a single assembly. The rear fuselage incorporates an equipment bay and houses the rocket motor closed by a detachable cowling, the fuel and oxidiser filling connectors are located on the rear fuselage backplate

The delta wings are stressed-skin titanium structures utilising a symmetrical airfoil. There are no ailerons; roll control is exercised by the differentially movable stabilators. The dorsal fin is all-movable for directional control. The ventral fin serves to enhance directional stability, it folds to starboard for ground handling and remains in that position while the missile is on the pylon, unfolding automatically after launch A special welded steel frame equipped with sensors restricts the control surfaces' movement and serves for their automatic monitoring in flight while the missile is on the pylon; this device is attached to the backplate and is jettisoned at the moment of launch, freeing the controls

The R201-300 liquid-propellant rocket motor developed by the Moscow-based OKB-300 under Sergey K. Tumanskiy (better known for its turbojet engines) is a twin-chamber unit with turbine pumps delivering

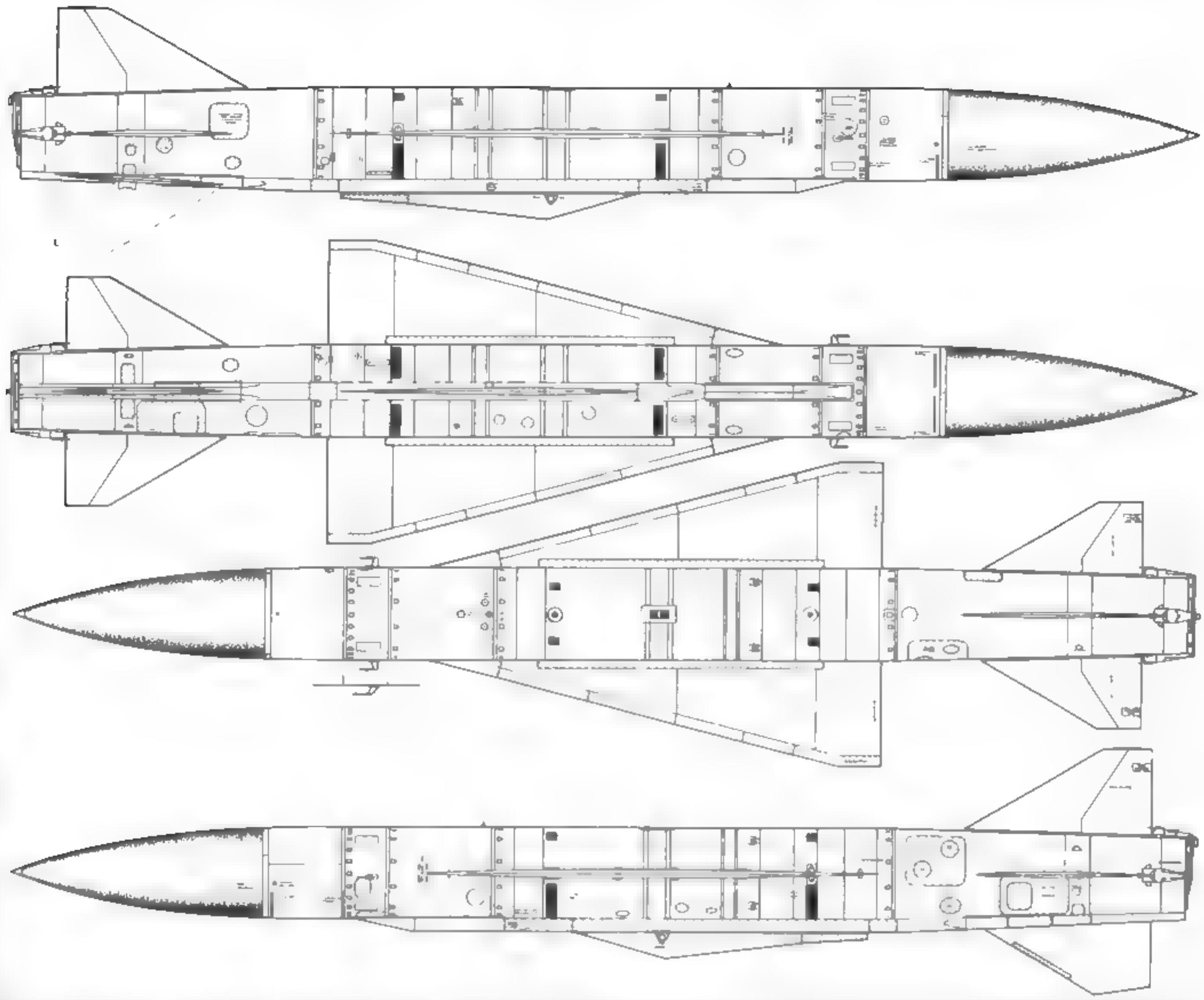


A Kh-22MPSI equipped on its ground handling dolly Note the metal nose with a ventral dielectric panel housing a PSI self-contained three-beam Doppler dead reckoning system. The number 16152 on the fin is probably the last five of the missile's c/n.



Above, top to bottom: the Kh-22PSI (with a scrap view of the forward fuselage underside), the Kh-22M/Kh-22N/Kh-22MN with a PMG seeker head; front view of the Kh-22PSI with the ventral fin unfolded; rear views of the Kh-22 (centre, with the control surface locking frame in place) and Kh-22M; and the Kh-22MPSI

Below: A Kh-22M suspended on the BD-45F centreline pylon of a Tu-22M0 prototype in fully lowered (pre-launch) position.



Above: Four views of a Kh-22PG with a PG seeker head and a BN shaped-charge HE AP warhead. The scrap view below the upper view shows the PPD-2K pitot head fitted instead of the port TP-156 pitot on some examples.

Below: A Kh-22PG (curiously, not a Kh-22M – note the lack of a forward dielectric portion on the ventral strake!) on the starboard BD-45K pylon of a Tu-22M3.

the fuel and oxidiser. The booster and cruise chambers are located above one another and have separate nozzles. In launch mode (with both chambers running) the R201-300 delivers 8,350 kgp (18,410 lbst) at 10,000 m (32,810 ft), cruise thrust at Mach 3.4 and 25,000 m (82 020 ft) is 650-1,400 kgp (1,430-3,090 lbst)

The Kh-22's range when used against large-area targets depends on the Tu-22K's speed and flight level at the moment of launch Thus, in the event of a launch at 950 km/h (590 mph) and 10,000 m the range is 400 km (248 miles), increasing to 550 km (341 miles) if launched at 1,720 km/h (1,068 mph) and 14,000 m (45 930 ft)

Flight tests of the Kh-22 commenced in July 1961, using the two prototypes of the Tu-22K – '24 Black' (c/n 5060045, fuselage number 604) and '25 Black' (c/n unknown, f/n 605) – as the launch platforms, and were concluded by the official service introduction of the K-22 weapons system in 1967 Before that, the missile's guidance system had been put through its paces on the Tu-16K-22 avionics testbed

A third version, the Kh-22P, was brought out later. As the P suffix (for *passivnaya* [*golovka samonavedeniya*]) indicates, this is an anti-radiation missile for use against AD radars. The Kh-22P was carried by the Tu-22KP/Tu-22KPD, a suitably modified version of the Tu-22K/Tu-22KD featuring a radar detection/target indication system

Kh-22M cruise missile

A new weapons system designated K-22M entered Soviet Air Force service in 1979. It consisted of the Tu-22M multi-mode supersonic bomber/missile strike aircraft (a new 'swing-wing' design totally unrelated to the earlier Tu-22, hence the new NATO reporting name *Backfire*), the updated Kh-22M air-to-surface missile and a new guidance system. Unlike the Tu-22K/Tu-22KD, the production Tu-22M2 *Backfire-B* and Tu 22M3 *Backfire-C* are able to carry up to three missiles at once two on BD-45K pylons under the wing gloves and one on a BD-45F hydraulically actuated centreline pylon in semi-recessed position

The Kh-22M (*modifitseerovannaya*) is an improved version of the Kh-22. Outwardly it differs little from the original model, lacking the jettisonable control surface locking frame and featuring a folding upper fin tip that allows the missile to be carried on the wing hardpoints. However, there's more than meets the eye. the Kh-22M is powered by a new Isayev S5.33M twin-chamber liquid-propellant rocket motor The S5 33M has three operational modes; in launch mode, with both chambers running, it delivers 7,000 kgp (15,430 lbst) at 10,000 m (32,810 ft). In cruise flight the one operating chamber generates either 600 kgp (1,320 lbst) or 1,300 kgp (2,865 lbst), depending on the fuel delivery rate, the cruise chamber can repeatedly switch between these modes of operation in order to maintain the required flight speed

Another difference lies in the control system which includes the modified APK-22A autopilot. When carried by the Tu-22M the Kh-22M has a maximum launch altitude of 16,000 m (52,490 ft). It can also be carried by the Tu-22K/KD, but this requires certain updates to be made to the aircraft's mission avionics

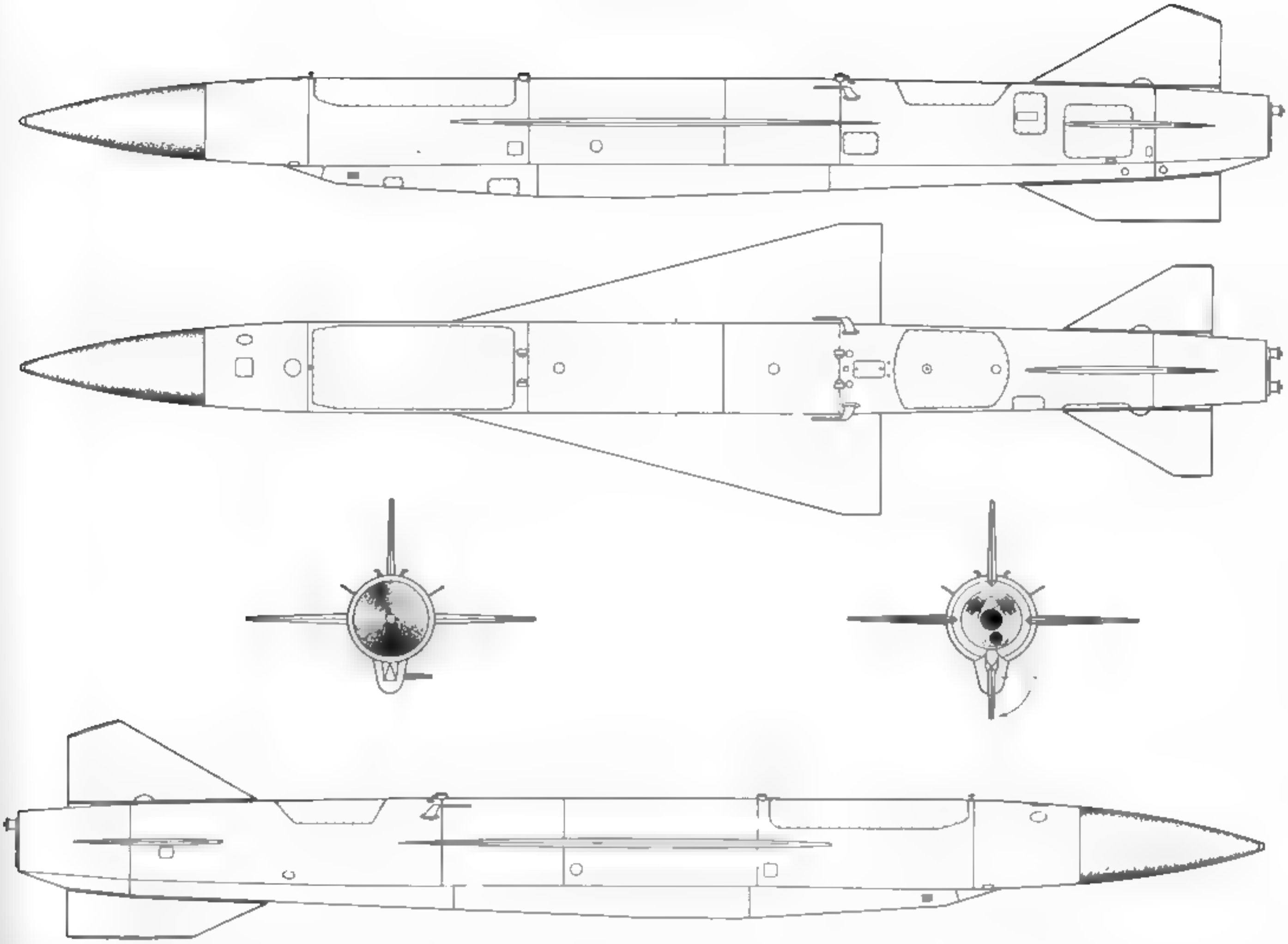
Actually the Kh-22M entered service ahead of the *Backfire* when the Tu-95K-22 *Bear-G* missile strike aircraft was introduced into the Soviet Air Force inventory in 1975 This is an upgrade of the Tu-95KM carrying two Kh-22M missiles on pylons under the wing roots instead of a single Kh-20M on the centreline

Like its immediate precursor, the Kh 22M is available in three versions with different guidance systems. The basic Kh-22M is equipped with a modified PMG active radar seeker head, while the Kh-22MPSI shares the dead reckoning system with the Kh-22PSI, there is also a Kh-22MP anti-radiation missile with a passive radar seeker head

Kh-22N cruise missile

A new version of the missile, the Kh-22N was added to the weapons range of the Tu-22M M3, Tu-22K/KD and Tu-95K-22 in 1976 Its main new feature is that the missile has two launch altitude ranges – high (8,000-13,000 m/26,250-42,650 ft) and low (1,000-8,000 m/3,280-26,250 ft); the latter range explains the N suffix standing for *nizkovysotnaya* – low-altitude Having picked a target, the navigator enters the appropriate launch altitude range and actual release altitude into the missile's guidance system. Hence the Kh-22N has appropriately modified guidance equipment and an APK-22M autopilot For each launch altitude range the missile's control system has specific guidance signal amplification quotients; accordingly the control surface movements in response to the same signal are also different, making for greater guidance accuracy. The cruise altitude is 12,000 m (39,370 ft) for the low range and 23,000 m (75,460 ft) for the high range

The Yak-28N 'Wild Weasel *Brewer*' development aircraft ('12 Yellow') with two Kh-28 anti-radiation missiles under the outer wings.



Five views of the Kh-28 anti-radiation missile. Note the folding ventral fin

The low launch altitude range was introduced to maximise air defence penetration probability. In the event of a low-range launch the missile's cruising speed is restricted to Mach 2.2 or 2,200 km/h (1,366 mph).

The Kh-22N is powered by a modified Isayev S5 44 rocket motor which differs from the S5.33 in having an extended continuous operation time in all modes, including a tripled operation time in the second mode (that is, with a 600-kgp rating) at low altitudes Depending on the launch altitude, the missile's maximum 'kill' range is 200-360 km (124-223 miles) in the high range and 80-240 km (50-149 miles) in the low range.

Once again, the Kh-22N comes in two versions featuring different guidance systems (PMG or PSI) and accordingly different warheads (nuclear/conventional or nuclear only). The dead reckoning variety with the PSI system is designated Kh-22NA.

Kh-22MN cruise missile

As the designation implies, the Kh-22MN is a cross-breed between the Kh-22M and the Kh-22N, being based on the former version but incorporating all the new features of the latter

Unlike the Kh-22N, the new version can be launched at altitudes up to 16,000 m when carried by the Tu-22M2/M3. Also, the rocket motor's operating time is further extended, increasing maximum 'kill' range to 380-570 km (236-354 miles) in the high range and 165-250 km (102-155 miles) in the low range.

Like all other versions of the missile, the Kh-22MN is available with an active radar homing or dead reckoning guidance system and accordingly different warheads

Kh-28 anti-radiation missile (*izdeliye* 93)

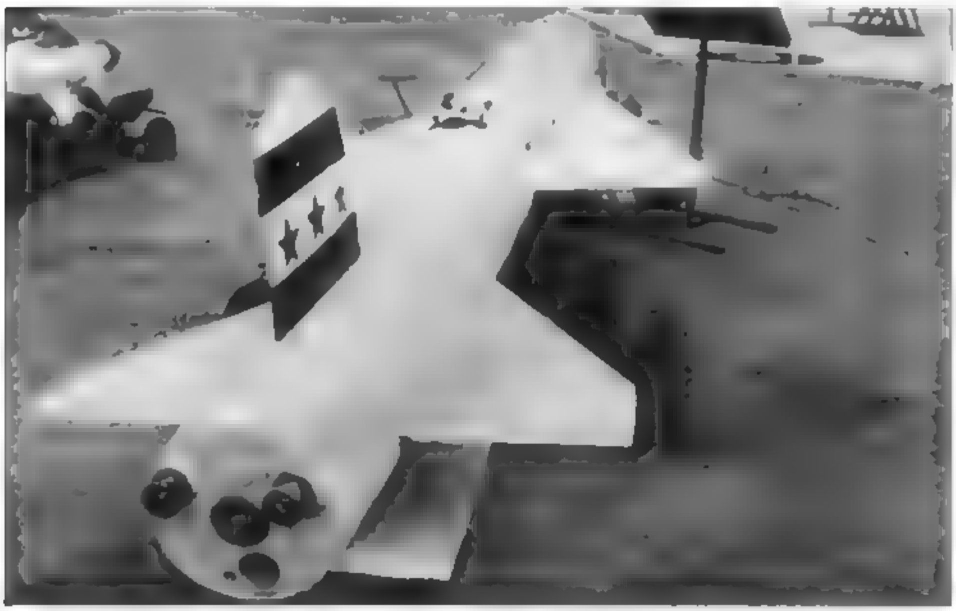
The Kh-28 cruise missile (*izdeliye* 93) is an ARM designed for destroying air defence radars, surface-to-air missile guidance radars and similar systems operating in three different wavebands. The missile was intended for carriage by tactical aircraft; hence, while sharing the aerodynamic layout of the Kh-22, it has smaller dimensions Another difference is that the airframe is made largely of aluminium alloys, not titanium and steel

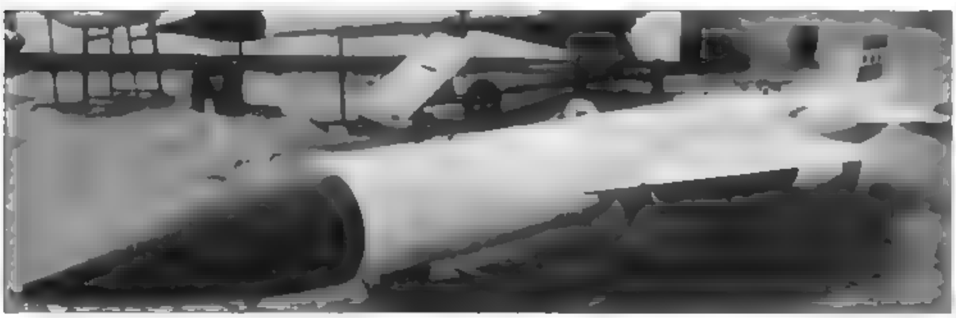
The forward fuselage section is divided into two bays, the first bay enclosed by a dielectric radome houses the guidance system, followed by the warhead in the second bay. The centre and rear fuselage sections are basically scaled-down versions of those of the Kh-22M A detachable ventral conduit housing wiring bundles, fuel and oxidiser pipelines and an ROV-5 optical proximity fuse runs the whole length of the fuselage, except for the radome

The low aspect ratio wings and tail surfaces are of trapezoidal planform. The wings have no ailerons, the dorsal fin and stabilisers are all-movable, while the ventral fin folds for ground handling and remains folded while the missile is on the wing. The control surfaces (dorsal fin and stabilisers) have 60° leading-edge sweep; the ventral fin has 65° leading-edge sweep.

	Kh-22	Kh-22M	Kh-22N	Kh-28
Codename				
US	AS-4A	AS-4B	AS-4C	AS-9
NATO (ASCC)	*Kitchen*	*Kitchen*	*Kitchen*	*Kyle*
Service entry	1964	n.a.	1976	1973
Length overall	11.77 m (38 ft 7 25/64 in)	11.65 m (38 ft 2 21/32 in)	11.67 m (38 ft 3 7/16 in)	6.036 m (19 ft 9 41/64 in)
Wing span	3.0 m (9 ft 10 1/8 in)	3.0 m (9 ft 10 1/8 in)	3.0 m (9 ft 10 1/8 in)	1.39 m (4 ft 6 47/64 in)
Wing sweep at quarter-chord	75°	75°	75°	75°
Fuselage diameter	0.92 m (3 ft 0 7/32 in)	0.92 m (3 ft 0 7/32 in)	0.92 m (3 ft 0 7/32 in)	0.43 m (1 ft 4 59/64 in)
Launch weight, kg (lb)	5,297-5,654 (12,266-12,464)	5,800-5,923 (12,790-13,057)	5,767-5,805 (12,713-12,797)	710 (1,565)
Warhead weight, kg (lb)	900 (1,980)	900 (1,980)	900 (1,980)	200 (440)
Launch range, km (miles)	250-350 (155-217)	370-500 (230-310)	80-360 (50-223)	120 (74.5)
Launch altitude, m (ft)	10,000-14,000 (32,810-45,930)	10,000-16,000 (32,810-52,490)	1,000-13,000 (3,280-42,650)	300-16,000 (980-52,490)
Flight altitude, m (ft)	22,500 (73,820)	22,500 (73,820)	12,500/22,500 (41,010/73,820)*	8,000/19,500 (26,250/62,335)
Speed, km/h (mph)	3,600 (2,236)	3,600 (2,236)	2,200/3,600 (1,366/2,236)*	3,400 (2,111)
Powerplant	Tumanskiy R201-300	Isayev S5.33M	Isayev S5.44	Tumanskiy R253-300
Missile platform	Tu-22K, Tu-22KP, Tu-22KD	Tu-22KD, Tu-22M/M2/M3, Tu-95K-22	Tu-22KD, Tu-22M/M2/M3, Tu-95K-22	Su-17M2/M3, Su-24, Yak-28N

* Figures for the two launch altitude ranges (high/low)



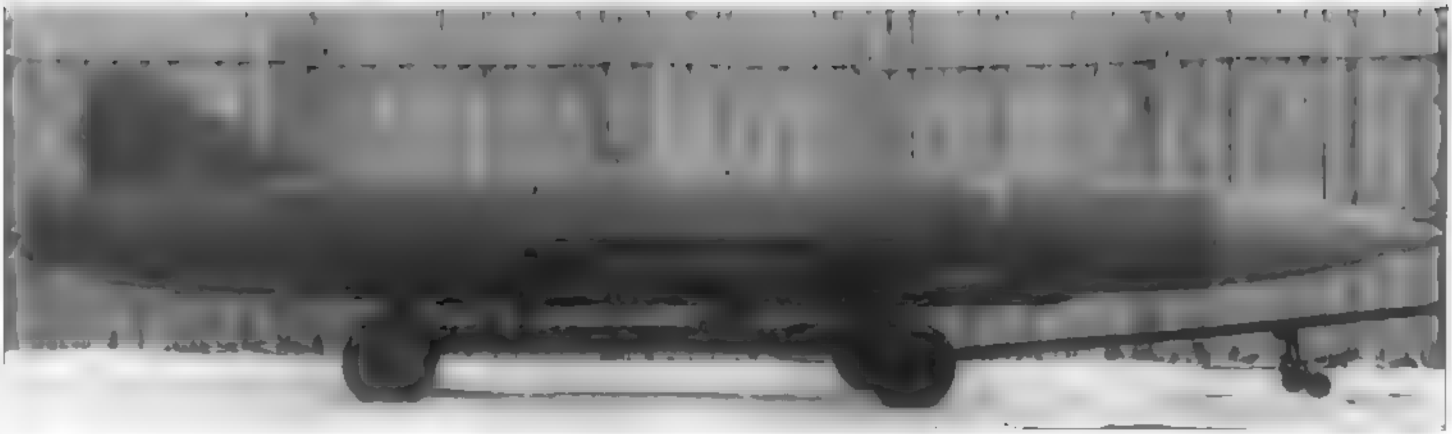


The rear fuselage houses a Tumanskiy R253-300 twin-chamber liquid-propellant rocket motor with turbine pumps delivering the fuel and oxidiser. It is rated at 1,220 kgp (2,690 lbst) in launch mode and 550 kgp (1,210 lbst) for cruise flight.

The missile's control system comprises a PRG-28 passive radar seeker head and an APR-28 autopilot. The PRG-28 scans the space ahead for working ground radars; having detected one, it supplies the target co-ordinates to the aircraft's targeting system, achieves a lock-on and tracks the target, generating control signals which are fed into the missile's autopilot. The latter brings the missile to the required flight level, stabilises it along all three axes and controls the missile's flight along a pre-programmed course or as commanded by the seeker head

Target information is downloaded from the aircraft to the autopilot's memory module prior to launch. As the missile falls away the control surface locks are released and the ventral fin unfolds; 1 3 seconds later the rocket motor ignites and the missile streaks

Left and above left: The export version of the Kh-28 is designated Kh-28E. Among other things, a certain quantity was supplied to Iraq; the example shown here was among the spoils of the Gulf War and the Iraqi flag on the fin was obviously applied by the Allies who captured it.



Above: A red-painted prototype KSR-5 missile on its ground handling dolly with the ventral fin folded.

away as the seeker head guides it. Twelve seconds after launch the autopilot initiates a programmed climb; three seconds later the rocket motor switches to cruise mode When the angle between the seeker head's radar beam and the direction of flight reaches 45°, the autopilot shuts down the rocket motor and the Kh-28 begins a dive, manoeuvring until the missile's axis is perfectly aligned towards the target.

The high-explosive warhead detonates when the missile is 5 m (16 ft) above the target, triggered by the optical fuse If a nuclear warhead is fitted, this is detonated by a special sensor at a preset altitude

The Kh-28 is carried by Sukhoi Su-17M2, Su-17M3 and (from 1975 onwards) suitably upgraded Su-17M fighter-bombers on a PU-28 pylon installed on the fuselage centreline. This requires a special *Metel'-A* (Snowstorm-A) radar detector/guidance pod to be carried on the starboard inboard wing pylon Early versions of the Su-24 'swing-wing' tactical bomber could carry a single Kh-28 on the port wing glove pylon, with a *Filin-N* (Horned Owl-N) radar detector/guidance pod suspended symmetrically to starboard, later batches of the Su-24 *sans suffixe* featured a built-in version of the Filin-N, which allowed them to carry two Kh-28s at a time Since the ARM's seeker head had to be pre-tuned to the target radar's operating frequency on the ground, suppression of enemy air defences (SEAD) missions were flown by pairs of Su-24s operating consecutively as 'hunter-killer' pairs Quite simply, the first aircraft would reconnoitre the air defences and transmit the relevant information back to base where the second aircraft (armed with Kh-28s) was waiting; the missiles would be promptly tuned and the other aircraft would take off to carry out the strike.

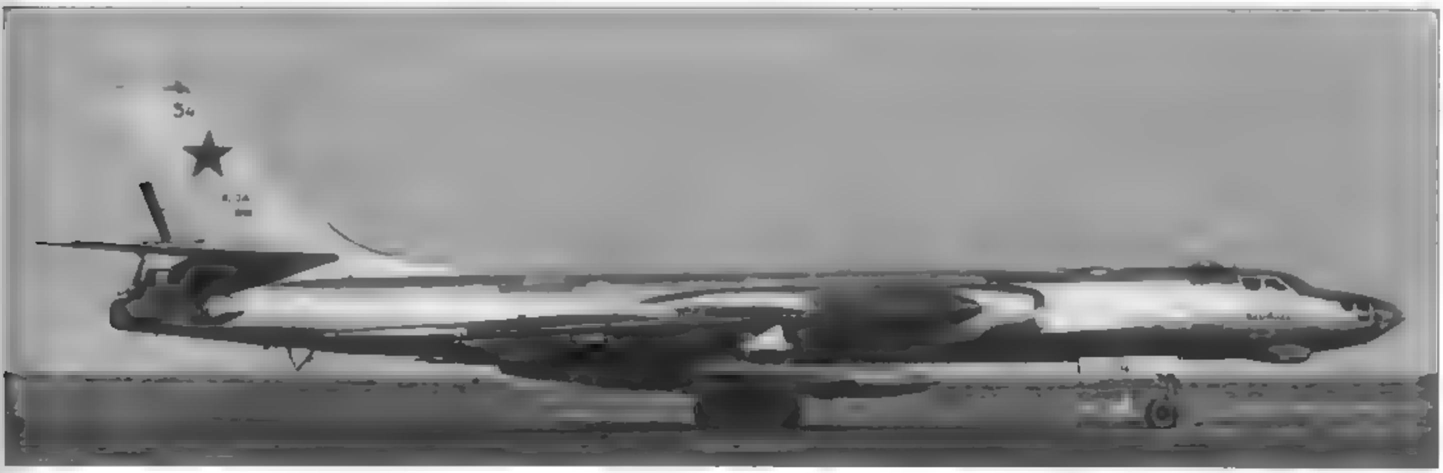
In addition to the above types, the Yakovlev Yak-28N SEAD (or 'Wild Weasel') aircraft was tested but did not enter service The Yak-28N also carried a pair of Kh-28s on pylons outboard of the engine nacelles, the associated guidance equipment was installed in the large radome normally occupied by the *Initsiativa* (Initiative) navigation/bomb-aiming radar. A similar test programme was held in 1970 with the An-12BL SEAD/transport aircraft (!) – a spin-off of the An-12B armed with four Kh-28s, two of which were carried on pylons flanking the forward fuselage and the other two under the outer wings. The guidance antenna was installed in a thimble radome in the nose ahead of the navigator's glazing

KSR-5 cruise missile; KSR-5P anti-radiation missile

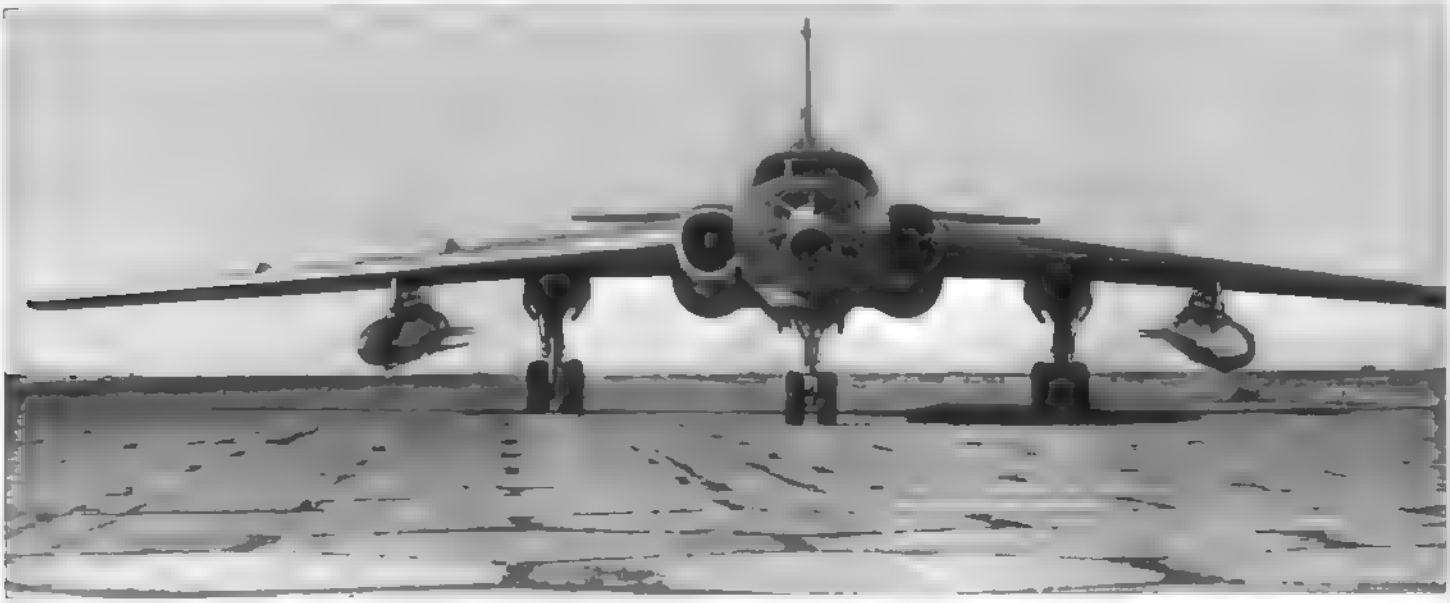
In 1974 the Soviet Naval Air Arm started operation of the new K-26 and K-10-26 weapons systems. These were based on the Tu-16K-26 and the Tu-16K-10-26 (an upgraded Tu-16K-10) respectively, both of which carried two KSR-5 anti-shipping cruise missiles on underwing pylons; the Tu-16K-10-26 retained the ability to carry a semi-recessed K-10 into the bargain.

The KSR-5 emerged as a logical development of the Kh-22 and the Kh-28. It was similar to both of them in aerodynamics and structural design but was sized somewhere in between. Of all the cruise missiles in the Kh-22/Kh-28/KSR-5 family, the KSR-5 turned out to be the most effective means of destroying marine targets with a high radar signature and pinpoint ground targets in all weather conditions.

The missile has an active radar homing system comprising a VS-K guidance/com-

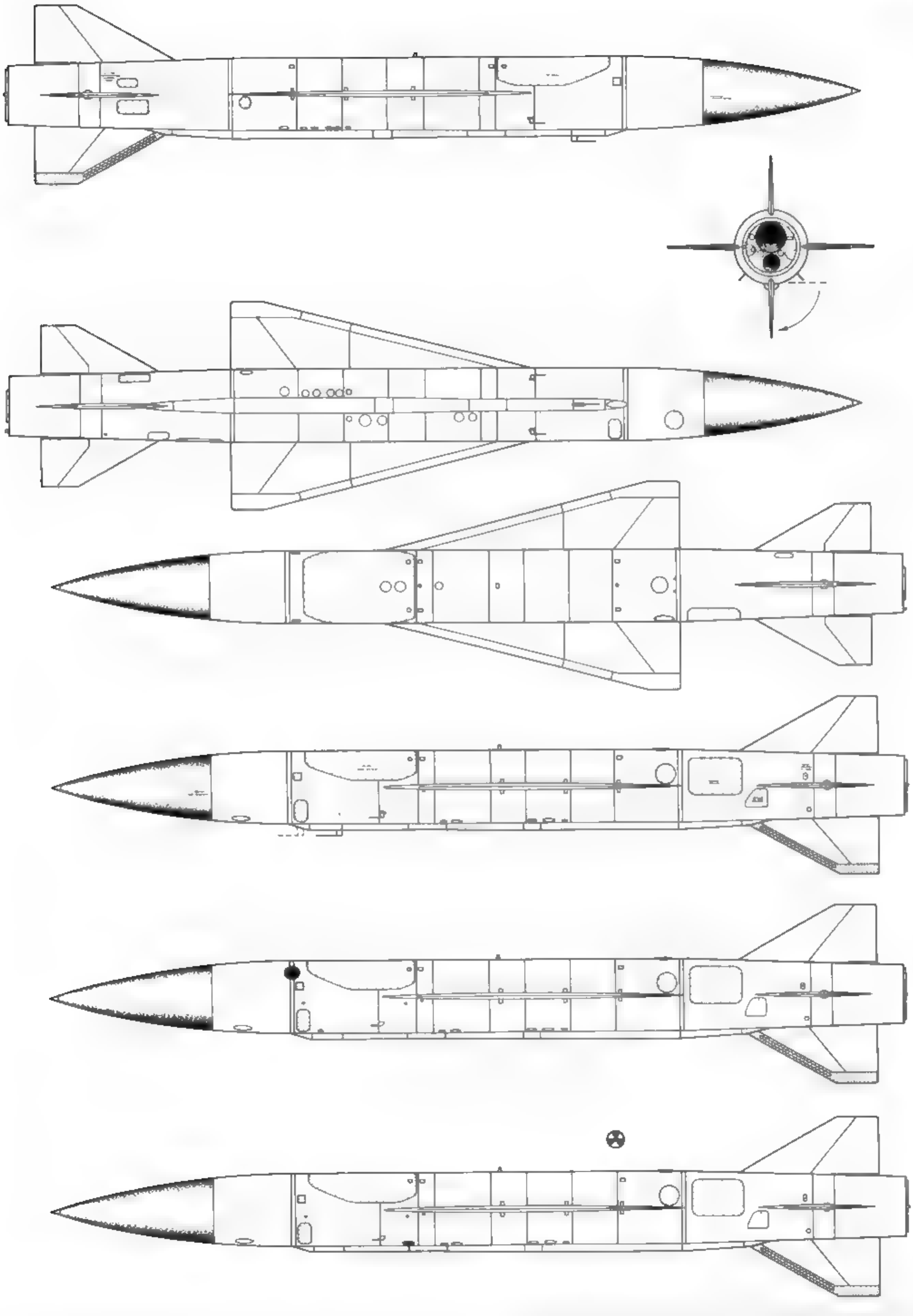


The Tu-16K-26 prototype ('54 Red', c/n 8204022, additional tail number 8191 – that is, 191st missile strike aircraft?) with a pair of KSR-5 missiles.

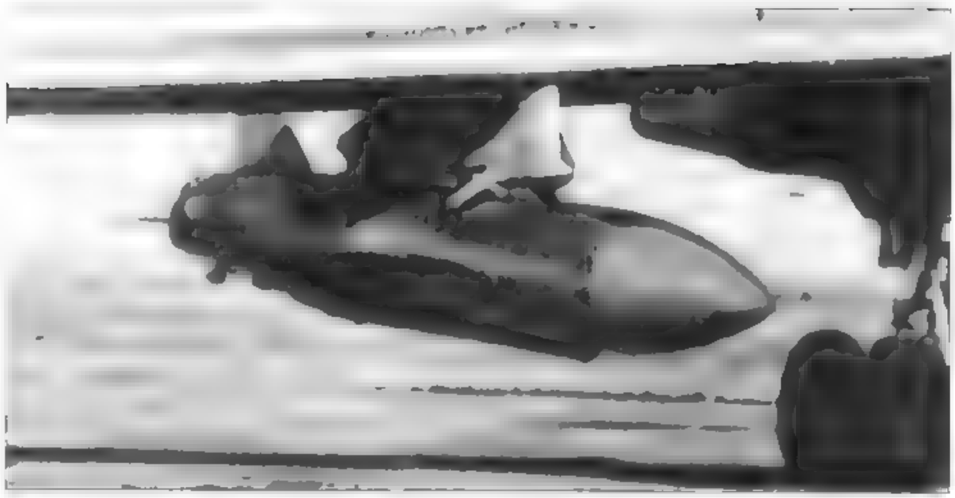


Three more views of the Tu-16K-26 prototype. Note the nose-down angle of the missiles and the characteristic inverted-T shaped antenna array on the navigator's station glazing frame; it is associated with the Ritsa radar detection and location system used for launching KSR-5P anti-radiation missiles.

Three views of a Tu-16K-10-26 with a full weapons load (two KSR-5s under the wings and a semi-recessed K-10S on the centreline). The rear view illustrates the smaller missiles' twin combustion chambers of unequal size.



Opposite page, top to bottom. Five views of a late-production KSR-5 or a KSR-5M; the hatched line on the port side view indicates the position of the pitot head on early batches of the KSR-5. The two bottom side views depict the KSR-5P (note the black circle marking at the manufacturing break and the ventral laser fuse port aft of this break) and the KSR-5N/KSR-5NM (note the ventral radar proximity fuse aerials)



Right: Close-up of the KSR-5 on the pylon. The missile shares the layout of the Kh-22 and the Kh-28 but is sized in between.

mand link subsystem, a BSU-7 autopilot, an altimeter and a speed sensor. The VS-K acquires the target while the missile is still on the wing, using target information supplied by the aircraft's radar – the Roobin-1KV in the case of the 'glass-nosed' Tu-16K-26 or the YeN-D of the 'duck-bill' Tu-16K-10-26. If the enemy sets up an ECM barrier, the guidance system makes use of the target co-ordinates stored in its memory, should the jamming become really severe and prolonged, the system switches to another operating frequency which hopefully is not yet jammed

The KSR-5 is launched at 9,000-11,000 m (29,530-36,090 ft); its flight trajectory is similar to that of the Kh-22, although the specific figures differ. After launching the missile the aircraft is free to manoeuvre at will or return to base The missile begins its terminal dive towards the target when the latter is 60 km (37¼ miles) away

The airframe is mostly made of aluminium alloys, with a dielectric nose radome The rear fuselage houses an S5 33 twin-chamber three-mode liquid-propellant rocket motor replaced by the S5 33A version on late production batches (as noted earlier, another version – the S5.33M – powers the Kh-22M). The S5 33 has two alternative operating programmes to suit different launch altitudes, but only one of them (optimised for the high launch altitude range) is used on the KSR-5 missile

A passive radar homing version designated KSR-5P was developed and fielded as an ARM designed for destroying shore-based and shipboard radars – both stable-frequency units and those whose operating parameters change smoothly or incrementally Outwardly the KSR-5P can be identified by the black circle markings of 200 mm (7⅞ in) diameter painted on above the fuselage waterline at the forward/centre fuselage joint. It is carried by the Tu-16K-26P – a Tu-16KSR-2-5-11 missile strike aircraft

	KSR-5	KSR-5N	KSR-5NM
Codename			
US	AS-6A	AS-6B	AS-6B
NATO (ASCC)	*Kingfish*	*Kingfish*	*Kingfish*
Service entry	1970	1976	n.a
Length overall	10.6 m (34 ft 9 21/64 in)	10.6 m (34 ft 9 21/64 in)	10.6 m (34 ft 9 21/64 in)
Wing span	2.606 m (8 ft 6 19/32 in)	2.606 m (8 ft 6 19/32 in)	2.606 m (8 ft 6 19/32 in)
Wing sweep at quarter-chord	75°	75°	75
Fuselage diameter	0.92 m (3 ft 0 7/32 in)	0.92 m (3 ft 0 7/32 in)	0 92 m (3 ft 0 7/32 in)
Launch weight, kg (lb)	3,850-3,930 (8 490-8,660)	3,870-3,950 (8.530-8,710)	n.a
Warhead weight, kg (lb)	900 (1,980)	900 (1,980)	none
Launch range, km (miles)	240 (149)	240/115 (149/71)*	110 (68)
Launch altitude, m (ft)	9,000-11,000 (29,530-36,090)	5,000-11 000/ 500-11,000 (16 400-36 090. (1,640-36,090)*	450-550 (1,480-1,800)
Flight altitude, m (ft)	22,500 (73,820)	22,500 (73,820)/ variable*	25-200 (80-660)
Speed, km/h (mph)	3,200 (1,987)	3,200/1,100-1,800 (1,987/683-1,118)*	1,100-1,800 (683-1,118)
Powerplant	Isayev S5.33	Isayev S5.33A	Isayev S5.33
Missile platform	Tu-16K-26 Tu-16K-10-26 Tu-95M-5	Tu-16K-26N Tu-16K-10-26N	Tu-16NM

* Figures for the two launch altitude ranges (high/low)

Top and above: A Tu-16K-26P with a modified avionics fit for working with KSR-5P ARMs The Tu-16K-26P can be identified by the extra 'thimble' radome in the extreme nose and the antenna pods on short pylons low on the forward fuselage sides

Below: A pair of Tu-16K-26s carrying KSR-5 missiles makes a flypast during the first 'open house' at Kubinka AB on 11th April 1992.

Right: The Tu-16K-10-26B was probably the most versatile version of the *Badger*, being capable of carrying free-fall bombs in addition to KSR-5 and K-10S missiles (though only a small bombload could be carried due to payload limitations) The external multiple bomb racks are visible under the fuselage immediately aft of the nosewheel well

upgraded with the ANP-K Plot (Raft) radar detection/guidance system which includes indicator modules borrowed from the Ritsa system. The two missiles can be launched against the same target or at different targets (one of which, however, has to be in line with the aircraft's line of flight), after which the aircraft is able to change course. The Tu-16K-26P and KSR-5P entered squadron service in 1979

KSR-5N cruise missile

In a similar way to the Kh-22N, this missile intended for use against single maritime or land targets with a high radar signature and large-area targets has two launch altitude ranges (high and low) with accordingly different flight trajectories, hence the N suffix indicating low-altitude capability In the high range the launch altitude varies from 5,000 to 11,000 m (16,400-36,090 ft), the maximum 'kill' range being 150-240 km (93-149 miles); alternatively, the missile can be launched at 500-5,000 m (1,640-16,400 ft) to a 'kill' range of 90-115 km (56-71 miles) Accordingly the guidance system is modified to give low-altitude capability, comprising a VS-KN guidance/command link subsystem, a BSU-7N autopilot and so on The appropriate launch programme is downloaded by the aircraft's navigator before launch

When launched at high altitude the KSR-5N follows the same flight path as a standard KSR 5 *sans suffixe* In the case of a low-altitude launch there is no climb and level flight – the missile simply proceeds towards the target in a shallow dive, using the shortest route possible

To make these flight profiles possible the KSR-5N is powered by a five-mode (!) S5 33A rocket motor. In a high-altitude launch (programme 1) modes 1, 2 and 3 are activated consecutively at 10,000 m (32,810 ft), 13,000 m (42 650 ft) and 22,500 m (73,820 ft) respectively to maintain the required speed of 3,200 km/h (1,987 mph) In a low-altitude launch (programme 2) modes 4 and 5 are activated at 10,000 m and 12,500 m (41,010 ft) respectively, accelerating the missile to 1,100-1,800 km/h (683-1,118 mph). Both rocket motor chambers run together in modes 1 and 4; only the cruise chamber is used in the other modes

The KSR-5N missile is carried by the Tu-16K-26N and the Tu-16K-10-26N, which again differ in equipment fit from the *Badger* versions carrying the basic KSR-5. Additionally, the prototype of the Tu-95M-5 missile strike aircraft (no code, c/n 8800601) carrying a single KSR-5N under each wing root underwent flight tests in 1976-77 but was not cleared for production because the more capable Tu-95MS armed with new-generation cruise missiles was already in the making (see Kh-55 below)

All KSR-5s in operational service had their guidance systems progressively updated to KSR-5N standard to achieve fleetwide maintenance and performance commonality; the missiles thus upgraded were known as KSR-5Bs Eventually most KSR-5s *sans suffixe* and KSR-5Bs were further upgraded to full KSR-5N standard receiving the designation KSR-5M

KSR-5NM target drone

A low-flying target drone version of the KSR-5N was developed as the KSR-5NM (***nizkovysotnaya mishen'***) to simulate air-to-ground and anti-shipping missiles for training air defence missile system crews. The drone is normally carried by the same aircraft as the live version; however, a specialised drone launcher version (the Tu-16NM) was also developed for the KSR-5NM by converting surplus Tu-16K-26s The drone is launched at 450-550 m (1,480-1,800 ft) and 500-550 km/h (310-341 mph) cruising at an altitude of 25-200 m (80-660 ft) and a speed varying from 203 to 640 m/sec (730-2,304 km/h, or 454-1,431 mph)

Close-up of the centre fuselage of the Tu-95M-5 development aircraft with two KSR-5N missiles on pylons under the wing roots

The Missiles of the Zvezda OKB

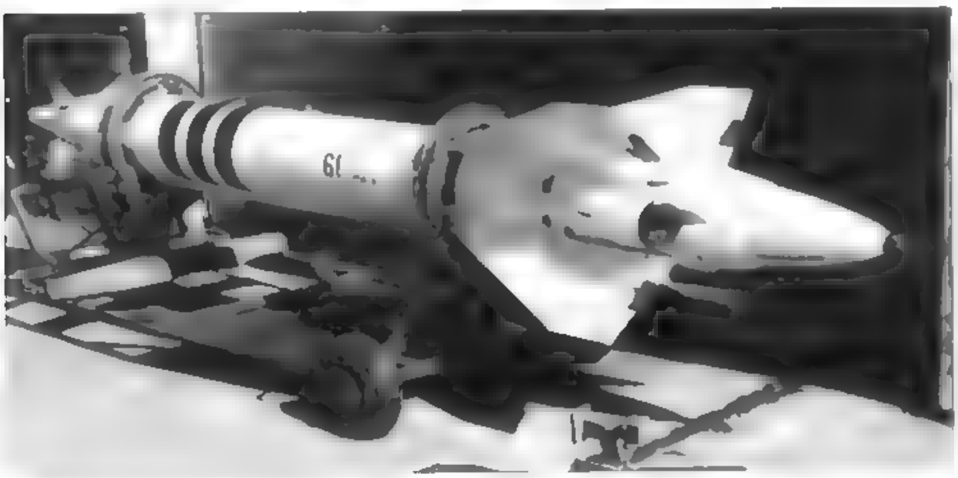
Back in the mid-1950s, when the K-5MS (RS-2-US) air-to-air missile was undergoing trials, the trials programme included assessment of the missile's suitability as an air-to-ground weapon. The Soviet Air Force State Research Institute named after Valeriy P. Chkalov (GK NII VVS – *Gosoodarstvennyy krasnoznamyonnyy naoochno-issledovatel'-skiy institoot Voyenno-vozdooshnykh seel*) and the plant manufacturing the RS-2-US held a series of live launches against various ground targets and surface ships, using the MiG-19PM interceptor as a makeshift strike aircraft. This was the Soviet Union's first experience with guided air-to-surface missiles (ASMs) for tactical aircraft. The results were encouraging, but it was recommended that the warhead weight be increased to enhance the missile's 'killing power'

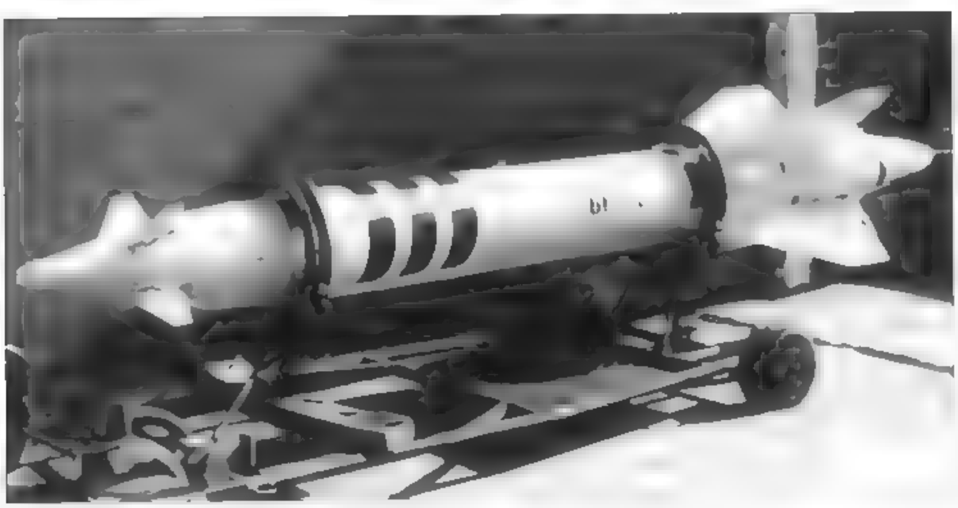
Meanwhile, in 1954 the Martin Aircraft Co. started work on the AGM-12 Bullpup air-to-surface missile designed as a fighter weapon; the missile was introduced into the US Navy inventory in 1959, being carried primarily by the Douglas A-4 Skyhawk shipboard attack aircraft. Similar weapons were under development in France at the same time; the AS-20 and AS-30 (AS = *air-sol* - air-to-surface [missile]) saw service with many NATO air arms

Taking account of all this, in 1965 the Soviet Council of Ministers ordered the development of the Kh-23 tactical ASM as a weapon for the new MiG-23 'swing-wing' tactical fighter. The design bureau headed by A. L. Lyapin was assigned responsibility for this programme

At that time the Soviet aircraft industry had no experience of developing missiles in this class. Hence the design bureau of MAP Machinery Plant No.901, a series production facility specialising in aircraft weapons, suggested using stock components of the RS-1-U, RS-2-U, R-8M, R-4 and other production AAMs manufactured there for air-to-surface missile development in order to save time. By then Plant No 901 and its design bureau had accumulated ten years of experience in manufacturing various classes of rockets and missiles. Besides, as mentioned in Chapter 1, the design bureau had developed a series of small and highly manoeuvrable target drones for training interceptor pilots in air-to-air missile attacks and created the R-55 AAM based on the components of production missiles. Considering all this, MAP and the Soviet Air Force tasked the plant with developing a missile in the same class as the Kh-23; the missile was designated Kh-66 (*izdeliye* 66)

For the purpose of developing the Kh-66 the existing design bureau was transformed into an OKB headed by Yuriy N. Korolyov in March 1966. When Korolyov died in 1973, V. N. Boogaiskiy succeeded him as head of the design establishment; prior to that he had worked for a long time at the Il'yushin OKB and other design bureaux. Three years later, in 1976, the enterprise was named the Zvezda (Star) OKB, since 1986 it has been headed by G. I Khokhlov, a disciple and fellow worker of Matus R. Bisnovat, who had previously held office as Chief Designer of NPO Molniya





Kh-66 air-to-surface missile (*izdeliye* 66)

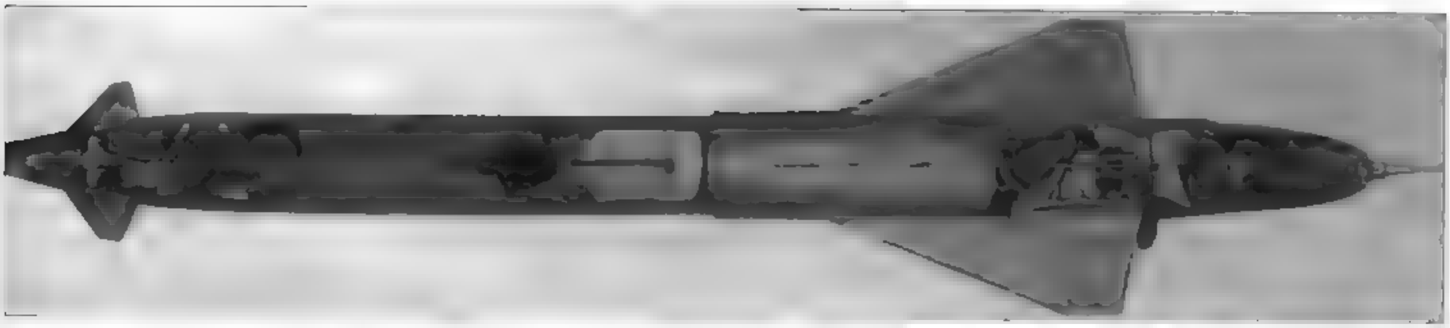
This missile was modelled both aerodynamically and structurally on the RS-2-US air-to-air missile developed by Pyotr D. Grooshin, featuring a canard layout with lateral nozzles. Moreover, the control system is borrowed from that missile in as-is condition, which allows the R-66 to be launched by the same fighters that carry the RS-2-US; this came as a significant and welcome boost to their operational capabilities

The Kh-66 utilises a solid-fuel rocket motor taken straight from the R-8 AAM, however, it is fitted with a specially designed bifurcated jetpipe with lateral nozzles. The need for this modification was caused by the placement of control system components in the tailcone *à la* RS-2-US

The forward section of the missile's body houses an all-new shaped-charge/high-explosive/fragmentation warhead. The warhead weight is 103 kg (227 lb), exceeding by far that of the RS-2-US; it is fitted with an impact fuse

The actual design work started in March 1966 and proceeded exceptionally fast; as early as September 1966 the first Kh-66s were undergoing trials on the MiG-21PFM fighter. The missile's accuracy initially fell short of the customer's requirements, but things got better when the fighter's fire con-

Left and above left: This zebra-striped Kh-66 is an inert Kh-66UD training/demonstration round (*oochebno-deystvuyushchaya [raketa]*), hence the partially obliterated '66УД' stencil. The missile shares the layout of the RS-2-US but the size and proportions are rather different. Note the design of the ground handling dolly with strut-mounted annular securing clamps.



Above: A cutaway drawing of the Kh-66. The small ailerons visible in the lower photo on the opposite page are not shown here.

trol radar was modified Trials showed that the Kh-66 was superior to unguided rockets, its advantages were amply demonstrated during an exercise held at GK NII VVS in 1968 when a ground radar was knocked out by a single Kh-66

In reality the missile was nothing but an interim solution. Its accuracy depended heavily on the launch range· at maximum range the reticle of the sight would obscure the small target and prevent the pilot from promptly correcting the missile's trajectory Despite this shortcoming, the Kh-66 was put into production and officially accepted for [redacted]

Kh-23 air-to-surface missile (*izdeliye* 68); Kh-23M air-to-surface missile (*izdeliye* 68M)

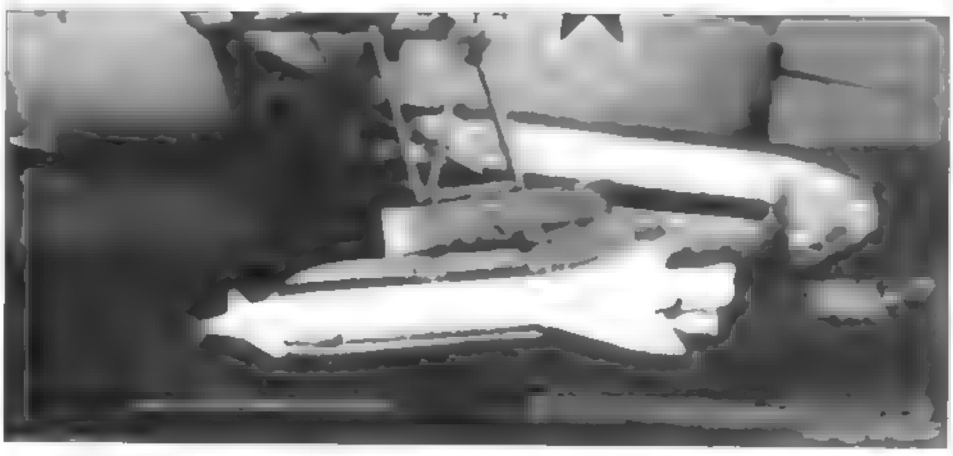
Concurrently with the development of the Kh-66 the future Zvezda OKB proceeded with the development of the Kh-23 ASM, a project it had taken over from A. L. Lyapin's OKB. By then the Soviet electronics industry had brought out the Del'ta radio command guidance system designed for air-to-ground missiles. The system's receiver components fitted neatly into the tail of the Kh-66 missile instead of the existing equipment, allowing the Kh-23 to be derived from the earlier model with a minimum of changes.

Outwardly the Kh-23 (*izdeliye* 68) differs from the Kh-66 only in the shape of the rear body section housing the guidance system. The guidance principles, however, are totally different; the Kh-66 is a beam-riding weapon making use of target illumination by the fighter's radar, whereas the Kh-23 is guided manually by means of radio commands. The pilot uses a mini-joystick on the aircraft's control stick to control the missile trying to superimpose the missile's blip on the targeting system screen with that of the target while keeping the latter in the sighting reticle

Sounds complicated? Exactly Here lies an inherent shortcoming of the new guidance system· keeping track of three different objects and trying to get them together while flying the aircraft at the same time is indeed rather difficult. This completely prevents the pilot from doing anything else (such as checking if he is under attack) and is detrimental to targeting accuracy in actual combat. Hence a ground simulator was developed in order to give the pilots some experience; the pilots usually got the hang of it after a few hours' training

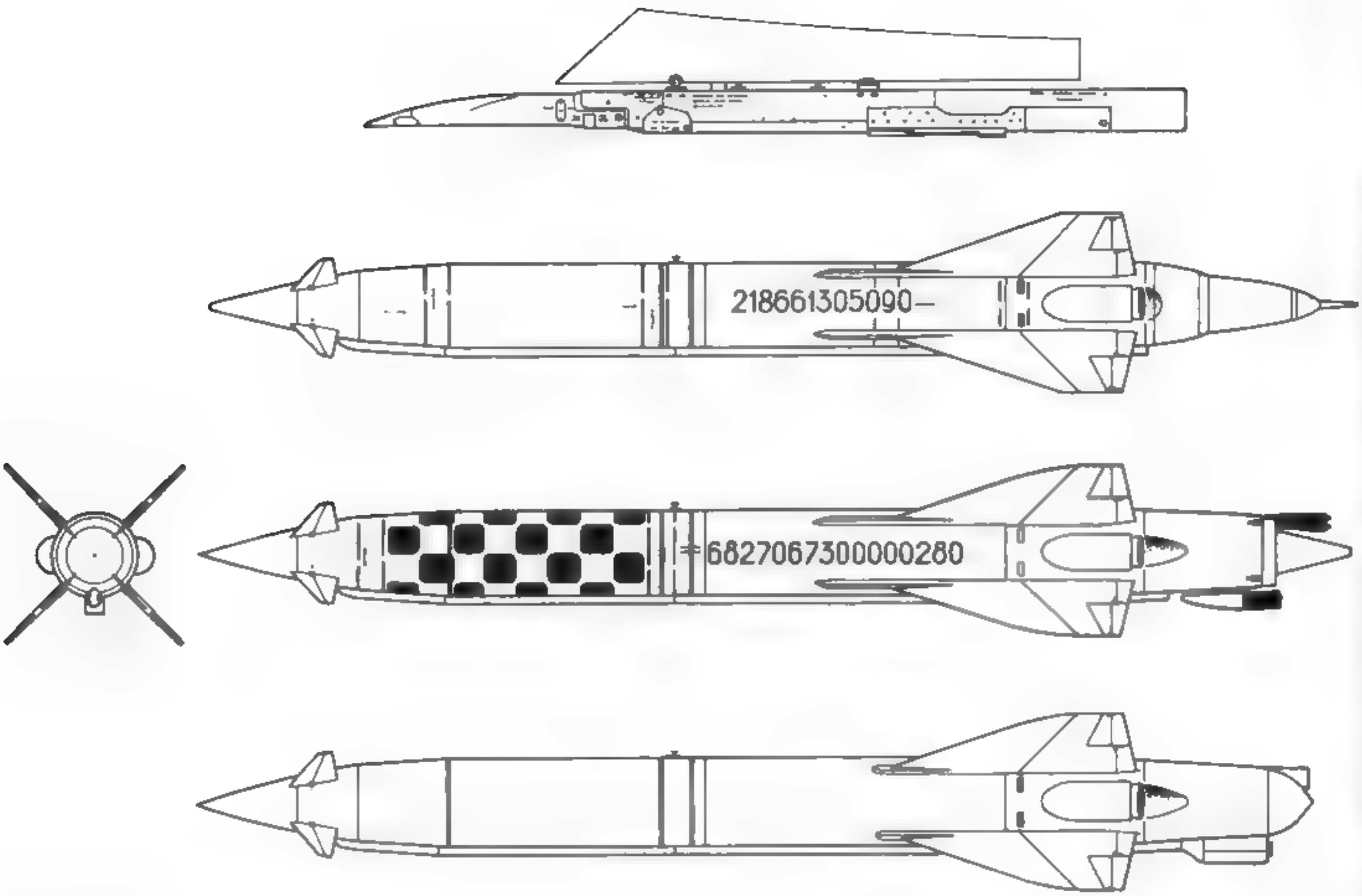
Another difference between the Kh-66 and the Kh-23 is the latter's higher-powered rocket motor utilising a different grade of solid fuel. Other changes are a tracer under the tailcone to assist visual tracking and modified wings with curved leading edges to improve the missile's aerodynamics; the wing span is reduced by 35 mm (1⅜ in)

Manufacturer's flight tests of the Kh-23 began in early 1968; a number of design flaws became apparent at this stage, causing the tests to drag on until the end of 1969 The problems encountered included difficulties with accommodating the associated guidance equipment on production aircraft to solve this problem a podded version of



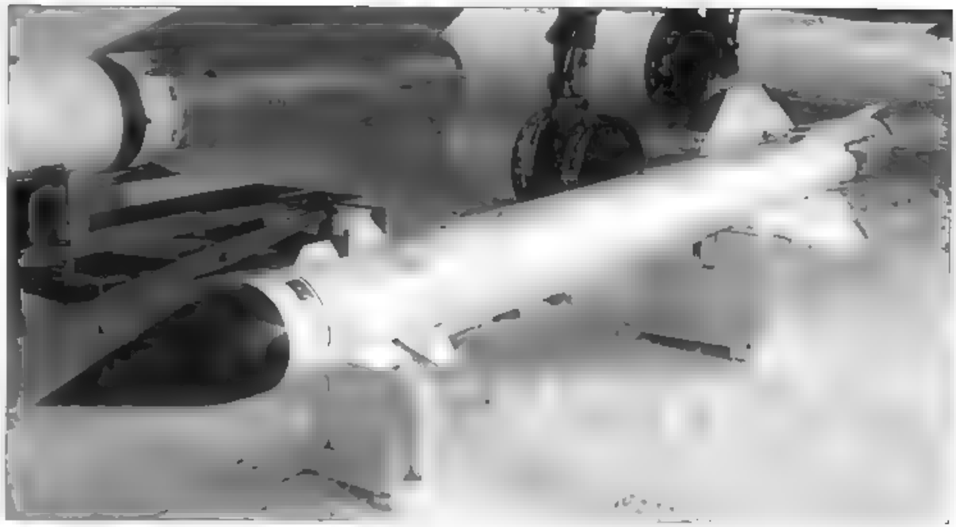
Above right· An Kh-23M training/demonstration round on the starboard wing glove pylon of a MiG-23UB trainer. The airframe is identical to the Kh-66, except for the tail section.

Right: Among other things, the Kh-23M was carried by an experimental version of the Mil' Mi-14 helicopter. The curious shape of the pylons was due to the main gear/flotation bag sponsons.



Top to bottom: The APU-68UM launch rail fitted to many Soviet tactical aircraft; a live Kh-66 missile; an instrumented test round version of the Kh-23; and the Kh-23M.

	[redacted]	Kh-23	[redacted]M
Codename			
US	AS-7	AS-7	AS-7
NATO (ASCC)	*Kerry*	*Kerry*	*Kerry*
Service entry	1968	1974	1975
Length overall	3 631 m (11 ft 10 9/64 in)	3 591 m (11 ft 9 3/8 in)	3 49 m (11 ft 5 13/32 in)
Wing span	0 82 m (2 ft 8 9/32 in)	0 785 m (2 ft 6 29/32 in)	0 785 m (2 ft 6 29/32 in)
Body diameter	0.275 m (10 53/64 in)	0 275 m (10 53/64 in)	0 275 m (10 53/64 in)
Launch weight kg (lb)	278 (612)	286 (630)	n a
Warhead weight, kg (lb)	103 (227)	108 (238)	108 (238)
Launch range, km (miles)	10 (6 2)	10 (6 2)	10 (6 2)
Launch altitude, m (ft)	500-5.000 (1 640-16.400)	80-5.000 (260-16,400)	80 5 000 (260 16 400)
Launch conditions	10-30° dive	Level flight or 10-30° dive	Level flight or 10 30° dive
Speed, m/sec (km/h, mph)	650 (2.340; 1,453)	700 (2,520; 1,565)	700 (2,520, 1,565)
Powerplant	PRD-204	PRD 228	PRD-228
Missile platform	MiG-21PFM	MiG 23 MiG 27 Su-17M *et seq* Su-24M Yak-38	MiG-23 MiG-27 Su-17M *et seq* Su-24M Yak 38



Right: The Kh-25MP anti-radiation missile fitted with a 2VP passive radar seeker head is one of the weapons carried by the MiG-29K shipboard fighter.

the system designated Del'ta-NG was developed, complementing the built-in Del'ta-N and Del'ta-NM versions

The state acceptance trials were quite lengthy, lasting from March 1970 to October 1973, but eventually the Kh-23 was cleared for production and service as a weapon for the MiG-23 tactical fighter and the MiG-23B fighter-bomber. In 1977 a further series of tests was undertaken in which the Kh-23 was launched by Kamov Ka-25 and Ka-27 shipboard anti-submarine warfare helicopters, as well as by the Mil' Mi-14PL shore-based ASW helicopter.

Kh-25 air-to-surface missile (*izdeliye* 69)

When firing the Kh-23 missile the pilot had to visually determine the target range, with frequent errors as a result; at high closing speeds, the Mk 1 eyeball is not a very good rangefinder. The advent of laser target designator for aircraft simplified the task a lot, all the pilot had to do was keep the aiming 'pipper' (and hence the laser beam) on the target. The maximum launch range was determined in each case by the moment when the missile's laser seeker head achieved a lock-on. This opened the possibility of aiming the missile even when the pilot had trouble seeing the target – the latter could be illuminated by a ground laser (for instance, a man-portable one), which was frequently done in actual warfare. The on-board version of the laser rangefinder/marked target seeker was designated *Prozhektor-1* (Searchlight-1).

The Kh-25 laser-guided missile (*izdeliye* 69) was brought out as a development of the Kh-23. This involved a redesign of the forward and aft body sections; the forward section housed a laser seeker head and a new autopilot ensuring more stable guidance. The Del'ta guidance equipment in the tailcone gave place to an additional 24-kg (53-lb) explosive charge; the main warhead was upgraded to increase its lethality – it was now of the high-explosive/fragmentation type and featured a more dense directional stream of penetrators

Flight tests of the Kh-25 commenced in February 1973, using the Su-7BM and Su-17M as the launch platforms. The tests showed that it was inexpedient to use the Kh 25 missile on the Su-7BM due to the low efficiency of the latter's ASP-5ND gunnery/bombing sight The Su-17MKG fighter-bomber equipped for carrying Kh-25 AGMs began its state acceptance trials in 1974, upon their completion the missile was added to the Soviet Air Force inventory The Kh-25 was part of the first Soviet laser-guided missile system enabling destruction of small ground targets illuminated by a laser designator, hence the designation Kh-25L (*lazernoye navedeniye* – laser guidance) sometimes applied retroactively to this missile to discern it from later versions

Later the Kh-25 was tested on various Mikoyan aircraft as part of an updated weapons system including the new ***Kaira*** (Guillemot) TV/laser rangefinder/sighting system which improved the system's capabilities appreciably. Again, in 1977 a series of tests was undertaken involving Kh-25 launches from Ka-25 and Ka-27 helicopters.

Kh-27PS anti-radiation missile (*izdeliye* 72?)

The Kh-66, Kh-23 and Kh-25 have a common weakness: these missiles can only be used effectively when the enemy air defences have been neutralised. Therefore, in 1972 the OKB then headed by Yuriy Korolyov began development of a passive radar homing missile designated Kh-27PS – an anti-radiation version of the Kh-25 designed for SEAD duties, hence the PS for ***passivnoye samonavedeniye*** (passive homing)

Since the Kh-27PS is to be launched before the aircraft comes within range of the enemy air defences (if at all possible), a new solid-fuel rocket motor was developed for it in order to increase the launch range several times as compared to the Kh-23 and Kh-25 While having identical dimensions and weight as the powerplants of these two missiles, the new motor delivers much greater thrust Another difference from the Kh-23 and Kh-25 is the new autopilot enabling programmed flight with a constant target bearing; this feature allows the missile to approach the target at the optimum angle, regardless of the launch distance

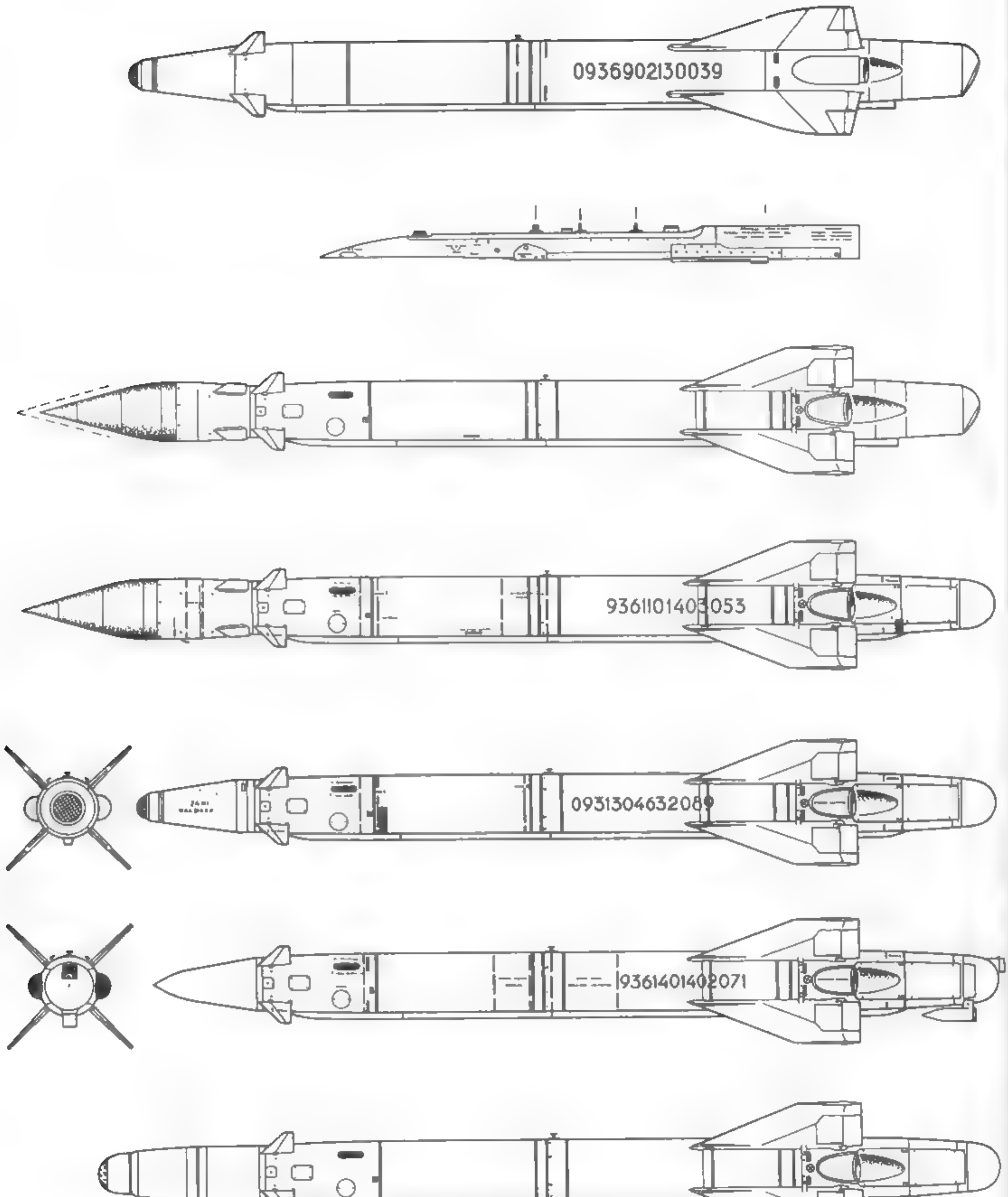
Outwardly the Kh-27PS differs from the Kh-25 in having greater overall length due to a longer forward body section tipped with a 1PG or 2PG seeker head in a conical dielectric radome An obvious identification feature is the provision of fixed canards (destabilisers) ahead of the rudders in order to retain adequate stability characteristics also, the Kh-27 has new wings but the wing span is unchanged

The ***V'yooga*** (Snowstorm) radar detection/guidance pod was specially developed for the Kh-27PS It controls the passive radar seeker head in target search mode while the missile is on the pylon, with due regard to flight level and the aircraft's attitude; it determines the permissible launch range, informs the pilot of the target's position relative to the aircraft and so on

State acceptance trials of the Kh-27PS were held, using the MiG-27 fighter-bomber as the launch platform. Stage A, which began in August 1975, involved using constant-emission radars as targets; the trials were continued in June 1977 with a modified seeker head capable of homing onto pulsed radars. Upon completion of the trials the Kh-27 was cleared for production and service. Depending on the seeker head version (1PG/continuous emission or 2PG/pulsed emission), the missile's length is 4.194 m (13 ft 9¼ in) or 4.294 m (14 ft 1 in) respectively.

Kh-25M air-to-surface missile (Kh-25MP/*izdeliye* 711, Kh-25ML/ *izdeliye* 713, Kh-25MR/*izdeliye* 714)

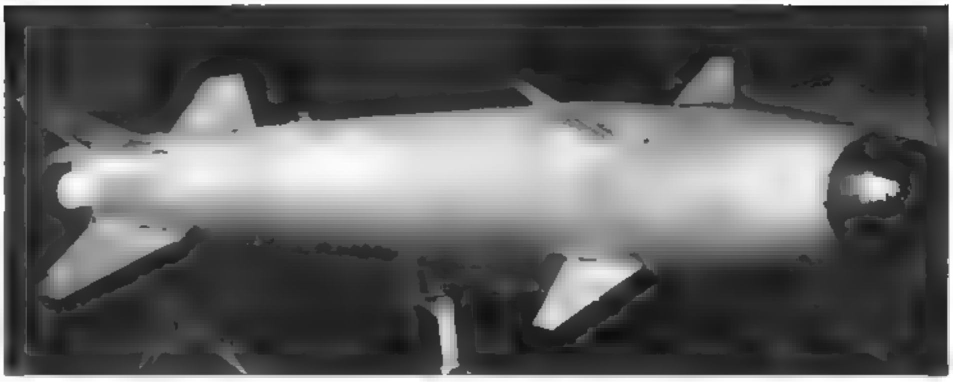
The policy of maximising the use of proven off-the-shelf components when designing new missiles and, conversely, upgrading production missiles by integrating components of new designs led to the development of the Kh-25M air-to-surface missile which entered Soviet Air Force service in 1981. The missile has a modular design; hence the M may just as well stand for ***modul'naya konstrooktsiya***, not ***modifitseerovannaya***. To add weight to this theory, the Kh-25M shares the principal compo-

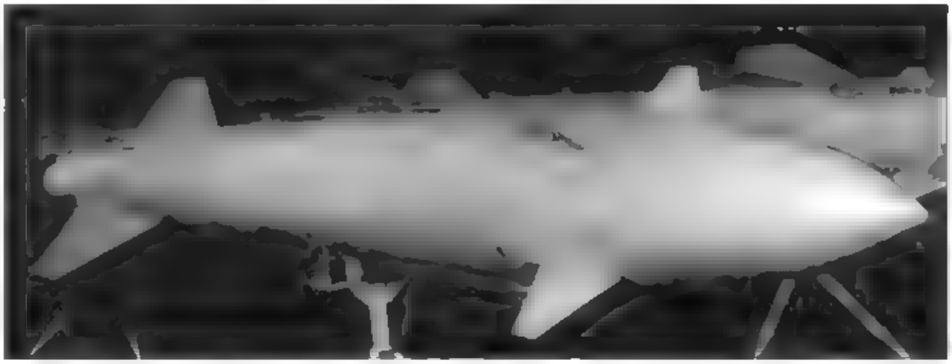


Top to bottom: the Kh-25 (Kh-25L); the APU-68UM3 launch rail; the Kh-27PS ARM with a 1PG seeker head (the hatched line shows the version with a 2PG seeker head), the Kh-25MP ARM; the laser-guided Kh-25ML; the radar-homing Kh-25MR, and the TV-guided Kh-25MT

Right: The laser-guided Kh-25ML identifiable by a conical nose with a small transparent window.

Below right: The radar-homing Kh-25MR has a radome with a double curvature. The missile's modular design facilitates installation of different guidance systems.





nents of the Kh-27PS ARM (the rocket motor, autopilot, warhead, electric generator module and wings) – in other words, it has nothing in common with the original Kh-25 except the designation.

Several interchangeable seeker heads are provided, allowing the missile to be configured for a specific mission, with an appropriate change in the designation. Thus the Kh-25MP (*izdeliye* 711) is an anti-radiation missile with a passive radar seeker head borrowed from the Kh-27PS; the Kh 25ML (*izdeliye* 713) has a laser seeker head identical to that of the Kh-25L, while the Kh-25MT has TV guidance (*televizionnaya sistema navedeniya*). The Kh-25MR (*izdeliye* 714) stands out from the lot, being equipped with a radio command guidance system taken from the Kh-23, hence the guidance system aerials are located in the tailcone, while the seeker head is substituted with a solid fairing. The aircraft's targeting system has to be changed accordingly and often the guidance equipment is carried in podded form.

It was not until MosAeroShow-92 (11th-16th August 1992) that the Kh-23, Kh-25 and Kh-27 were demonstrated to the general public for the first time. The missiles of this family are carried on APU-68UM or APU-68UM2 launch rails.

Kh-31 Taïfoon air-to-surface missile

The Kh-31 *Taïfoon* (Typhoon) multi-mission supersonic air-to-surface missile is characterised by its integrated powerplant comprising a solid-fuel booster and a ramjet sustainer. To reduce the missile's cross-section area and hence drag the booster is designed to fit into the ramjet nozzle like a plug and is ejected after burnout. The use of a ramjet has dramatically improved the missile's thrust/weight ratio throughout its operational envelope.

The Kh-31 utilises a conventional layout with aft-mounted all-movable cruciform rudders. The trapezoidal cruciform fins have

	[redacted]	Kh-25MP	Kh-25ML	Kh-25MR	Kh-25MT
Codename					
US	AS 10	AS-10	AS-10	AS-10	AS-10
NATO (ASCC)	*Karen*	*Karen*	*Karen*	*Karen*	*Karen*
Service entry	1975	1977	1976	1975	1976
Length overall	3.57 m (11 ft 8 1/2 in)	4 353 m (14 ft 3 3/8 in)	3 88 m (12 ft 8 3/4 in)	3 88 m (12 ft 6 25/32 in)	4 04 m (13 ft 3 in)
Wing span	0.785 m (2 ft 6 29/32 in)	0 785 m (2 ft 6 29/32 in)	0.785 m (2 ft 6 29/32 in)	0 785 m (2 ft 6 29/32 in)	0.785 m (2 ft 6 29/32 in)
Body diameter	0.275 m (10 53/64 in)	0.275 m (10 53/64 in)	0.275 m (10 53/64 in)	0 275 m (10 53/64 in)	0 275 m (10 53/64 in)
Launch weight, kg (lb)	320 (705)	310 (680)	300 (660)	320 (705)	300 (660)
Warhead weight, kg (lb)	136 (300)	90 (200)	90 (200)	140 (310)	90 (200)
Launch range, km (miles)	7 (4.34)	60 (37)	20 (12 4)	10 (6.2)	20 (12.4)
Launch altitude, m (ft)	500-4,000 (1,640-13,120)	n.a.	n a	n a.	n.a
Launch conditions	Level flight or 10-30° dive	In level flight, dive or climb	In level flight dive or climb	In level flight, dive or climb	In level flight, dive or climb
Speed, m/sec (km/h, mph)	700 (2,520; 1,565)	700 (2,520; 1,565)	700 (2 520; 1,565)	700 (2,520; 1,565)	650 (2,340; 1 453)
Powerplant	PRD-228	PRD 276	PRD-276	PRD-276	PRD-276
Missile platform	MiG-27M MiG-27K Su-17M2 *et seq* Su-24M Su-25	MiG 27M MiG 29K Su-17M Su-24M	MiG 27M MiG 29K Su 17M Su 24M	MiG-27M MiG 29K Su-17M Su 24M	MiG 27M MiG 29K Su 17M Su-24M

Left: A Kh-25 (Kh-25L) missile on an APU-68UM2 launch rail on the No 6 hardpoint of a Su-25 attack aircraft.

Below left: A Kh-25MR under the wing of a Su-25. The radar-homing version can be identified at this angle by the square aperture in the tailcone.

shorter span than the rudders 0 94 m (3 ft 1 in) versus 1.1 m (3 ft 7 9/32 in) and are located well aft

The forward body section houses the seeker head enclosed by a double-curvature radome, followed by the warhead and the fuel compartment of the ramjet sustainer The latter occupies the rear one-third of the missile's body. The ramjet breathes through four small circular intakes located around the body's circumference in two perpendicular planes (that is, the same planes as the fins and rudders). When the missile is on the pylon the intakes are closed by conical fairings with off-centre tips which are whisked away by the slipstream as the booster fires, and the arrangement gives the Kh-31 a very distinctive appearance. The air intake trunks blend into the housings of the control modules which are mounted on the rear body section Each module carries a fin and a rudder; inside are the powerplant control equipment, the electric power generators and the rudder actuators

The missile successfully passed its state acceptance trials in 1987-1990 with five alternative guidance systems. Of these, two versions are currently on the inventory the Kh-31A and the Kh-31P. They are carried, or meant to be carried, by Russia's Generation 4+ tactical aircraft – the MiG-29M multi-role fighter, the shipboard MiG-29K, the Su-27M (Su-35) multi-role combat aircraft and the Su-27IB (Su-34) fighter-bomber The Kh-31A (*izdeliye* 77) is an active radar homing anti-shipping missile, hence the A for ***aktivnoye samonavedeniye***, the Kh-31P is an anti-radiation missile, hence the P for *passivnoye* ***samonavedeniye*** (passive homing). The two versions are outwardly identical

The Kh-31 is carried on AKU-58 or AKU-58M ejector racks. On the Sukhoi types the missiles can be suspended both on the innermost wing hardpoints and under the air intake trunks; the MiG-29, which has a smaller ground clearance, can carry the Kh-31 under the wings only

The Kh-31 was publicly unveiled in both A and P versions at the MosAeroShow-92

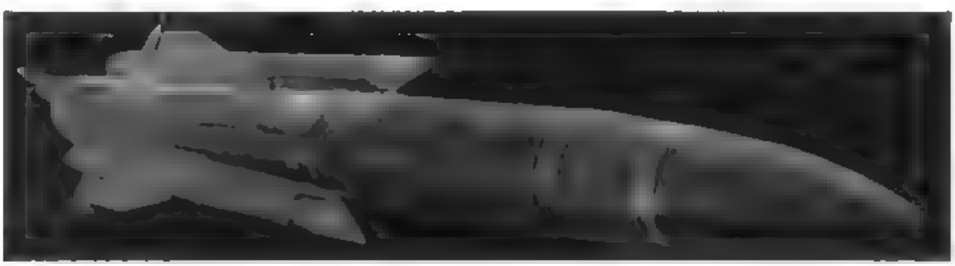
Kh-35 Uran cruise missile

This small subsonic cruise missile, whose Russian name (pronounced *oo**rahn***) translates as either 'Uranus' (the planet) or 'uranium', was one of the world's first air-to-surface missiles to feature a combined control/guidance system and a turbofan engine. Development began in 1983 and the missile was expected to be officially included into the Russian Air Force inventory in 1995

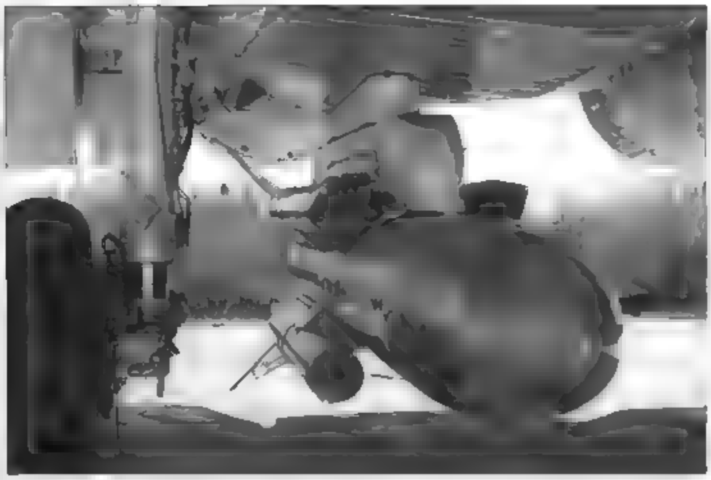
The Kh-35 utilises a conventional layout featuring folding cruciform wings and tail surfaces set at 45° to the horizontal plane The turbofan cruise engine buried in the rear fuselage breathes through a rectangular-section ventral air intake The missile has an HE/fragmentation/incendiary warhead

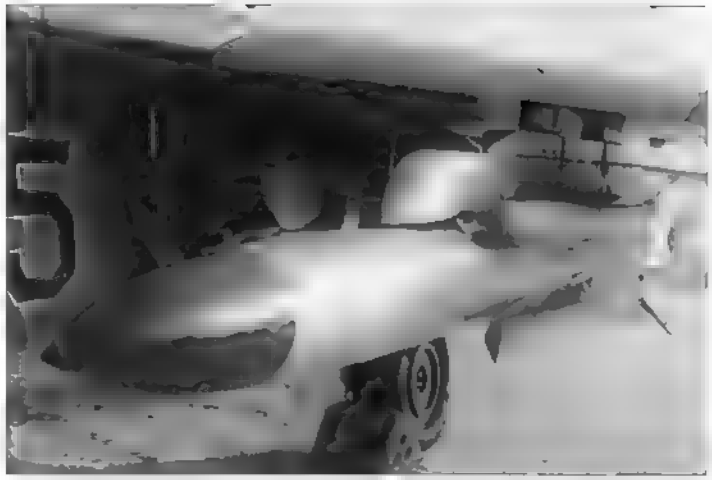
The combined control/guidance system comprises an inertial navigation system

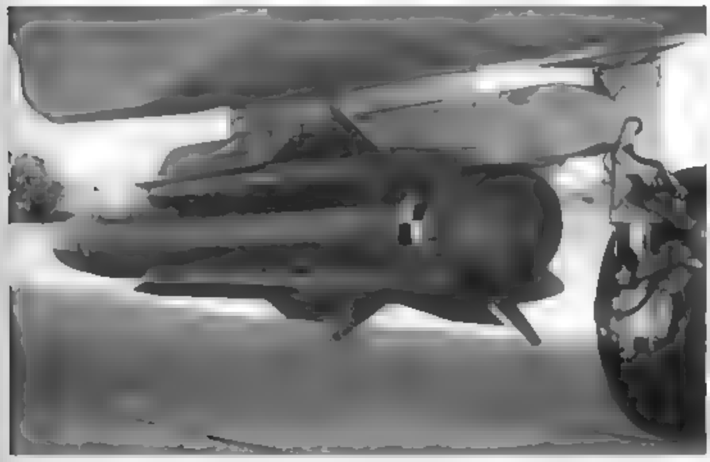
Above left: The Kh-31A anti-shipping missile with the solid-rocket booster and the ramjet intake covers in place

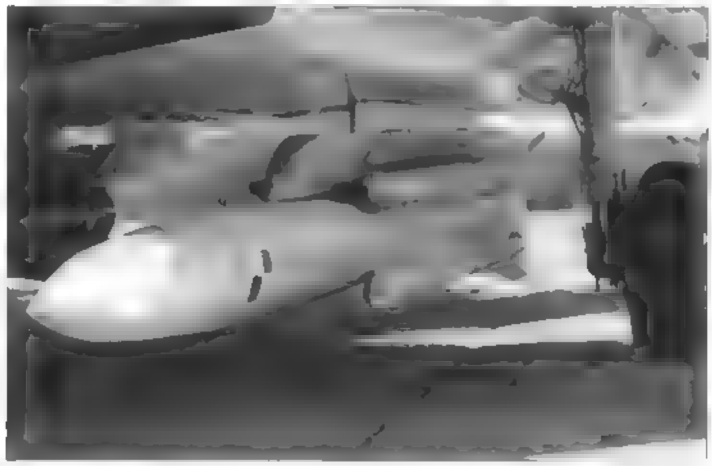


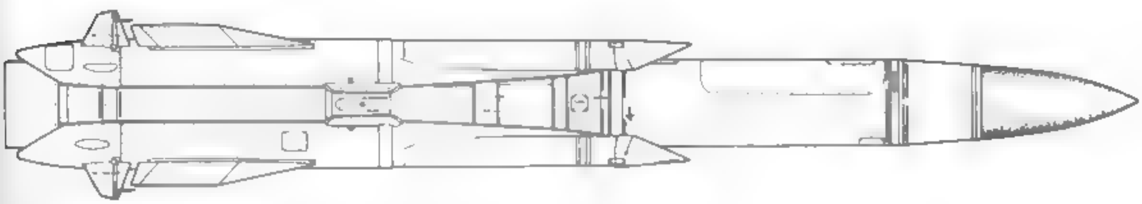
Right: The outwardly identical Kh-31P anti-radiation missile.

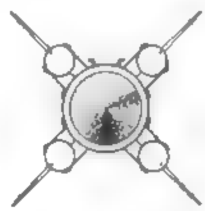










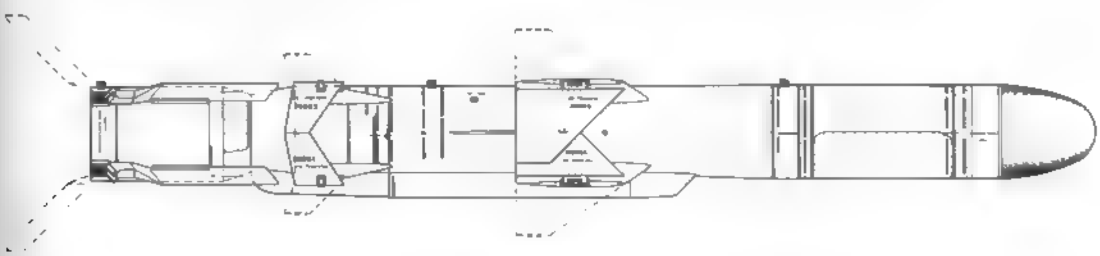


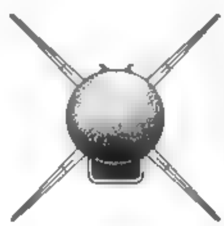
Top left, centre left and centre right: Orange-painted dummy Kh-31 missiles on AKU-58M ejector racks under the engine nacelles of the Su-27SKM prototype ('305 Grey'). Note the empty body of the booster and the black/white chequerboard photo calibration markings.

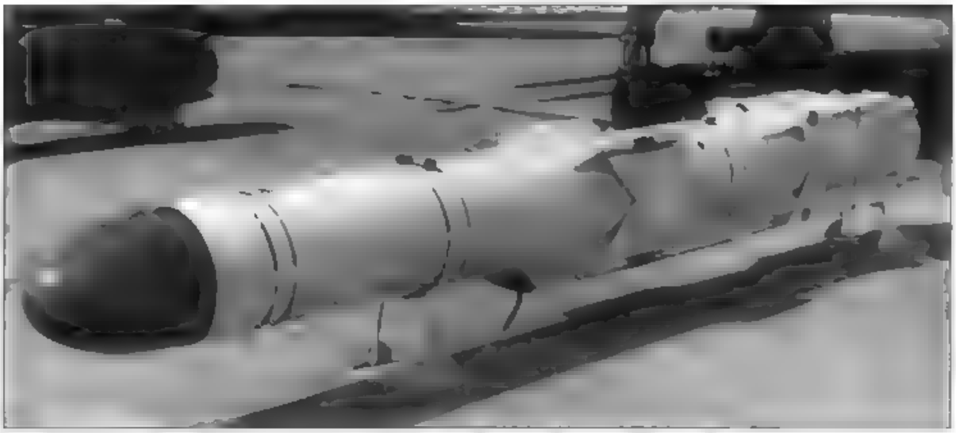
Top right: A Kh-31P on the port inboard wing pylon of MiG-29SMT '25 Blue'.

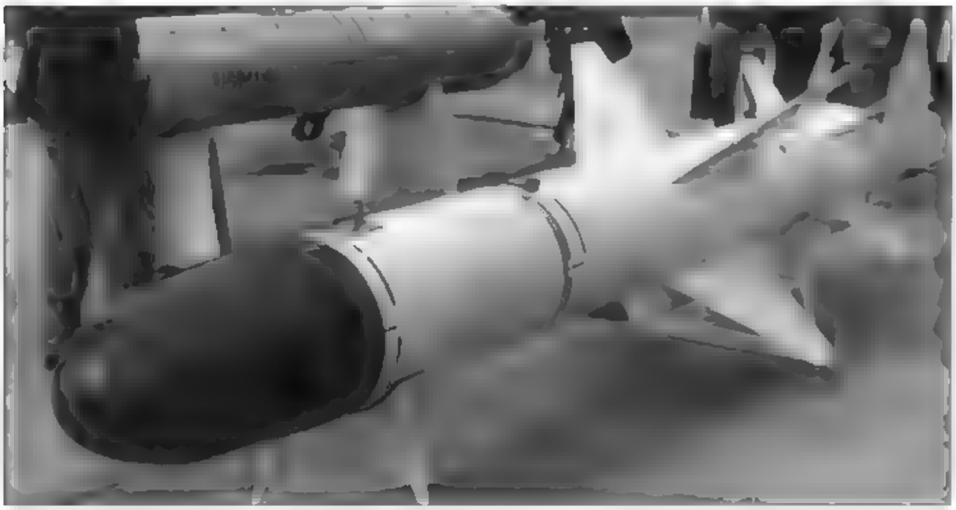
Above: Side and front views of the Kh-31A

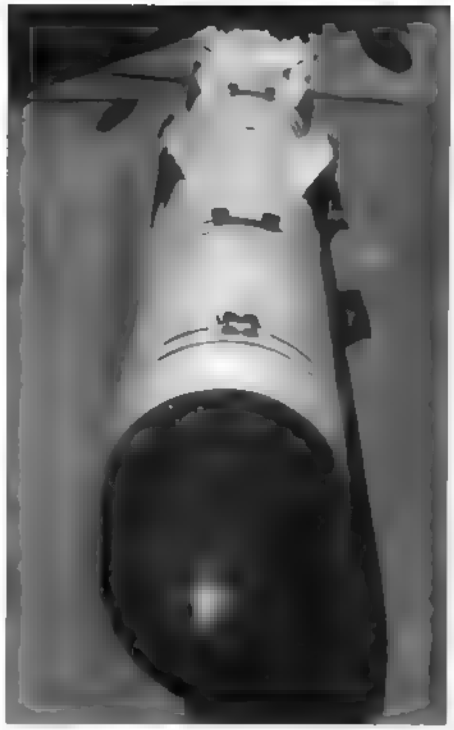
Below. The Kh-35 in pre-launch configuration; the hatched lines show the wings and rudders in deployed position.











Above left and above: A Kh-35 with the optional rocket booster attached and wings and rudders folded in the static park at one of the Moscow air shows. Note how the folded upper wings overlap the lower ones.

Left: Another Kh-35 with the wings and rudders deployed; no booster is fitted in this case. Note the differently painted radome.

	Kh-27PS	**Kh-31**	[redacted]
Codename			
US	AS-7	AS 12	AS-17
NATO (ASCC)	*Kerry*	*Kegler*	
Service entry	1977	1990	n a
Length overall	4.194/4 294 m* (13 ft 9¼ in/14 ft 1 in*)	4 557 m (14 ft 11 ⅜ in)	3 75 m (12 ft 3⅝ in)
Wing span	0.785 m (2 ft 6 29/32 in)	0 94 m (3 ft 1 in)	1 3 m (4 ft 3¾ in)
Body diameter	0.275 m (10 53/64 in)	0 36 m (1 ft 2 17/64 in)	0 42 m (1 ft 4 7/32 in)
Launch weight kg (lb)	302 (665)	690 (1,520)	480 (1 060)
Warhead weight, kg (lb)	89 (196)	90 (198)	145 (320)
Launch range, km (miles)	40 (25)	70 (43)	130 (80)
Launch altitude, m (ft)	50-12 000 (160-39 370)	50-15.000 (160-49,210)	Sea level / 5,000 (16,400)
Launch conditions	In level flight dive or climb		
Speed, m/sec (km/h mph)	880 (3 168 1,967)	1 000 (3,600, 2,263)	300 (1.080; 670)
Powerplant	PRD-276	Ramjet + solid-fuel rocket booster	Turbofan [+ optional solid-fuel rocket booster]
Missile platform	MiG-27M Su-17M3,M4 Su-24M MiG-29M	MiG 29M MiG-29K Su-27M Su-34 Su-25TM	

* Depending on seeker head version.

** 4 445 m (14 ft 7 in) with solid-fuel rocket booster

(INS) and an active radar homing system that comes into play at the terminal guidance phase. The active radar seeker head is virtually jam-proof, making the system immune to enemy ECM Another peculiarity of the Kh-35 making it hard to intercept and destroy is that the cruise flight takes place at an altitude of only 3-5 m (10-16 ft)

As of this writing the Kh-35 is used by the Russian Navy's surface ships as part of the 3M24 Uran offensive weapons system and forms part of the Bal-E (Ball, that is, festive occasion with dancing) mobile shore-based anti-shipping missile system, which is a defensive system. As distinct from the air-launched variety, the shipboard and shore-based versions are of necessity equipped with a solid-fuel rocket booster scabbed on to the aft extremity of the fuselage; this increases overall length in pre-launch condition from 3 75 m (12 ft 3¾ in) to 4.445 m (14 ft 7 in). To improve directional stability the booster features four folding fins similar to those found on pod-launched unguided rockets, it is jettisoned after burnout, by which time the turbofan is 'up and running' at cruise thrust

Once again the Kh-35 was displayed publicly for the first time at the MosAero-Show-92 complete with booster

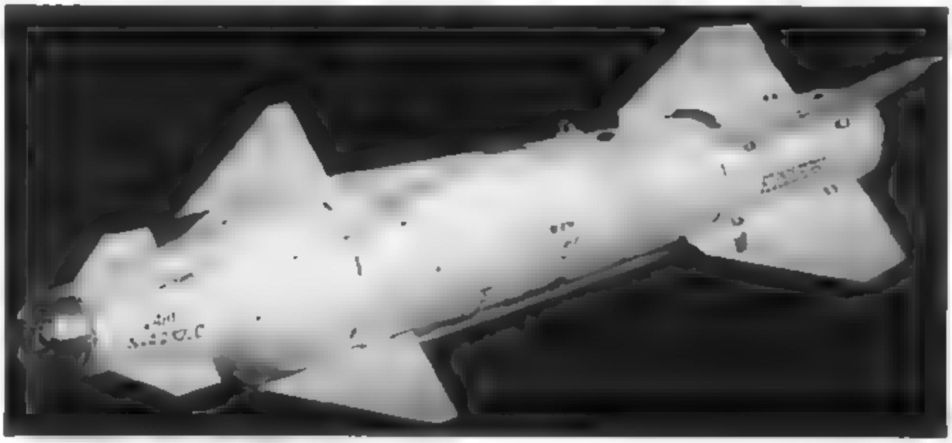
The Air-to-Surface Missiles of GMKB Vympel

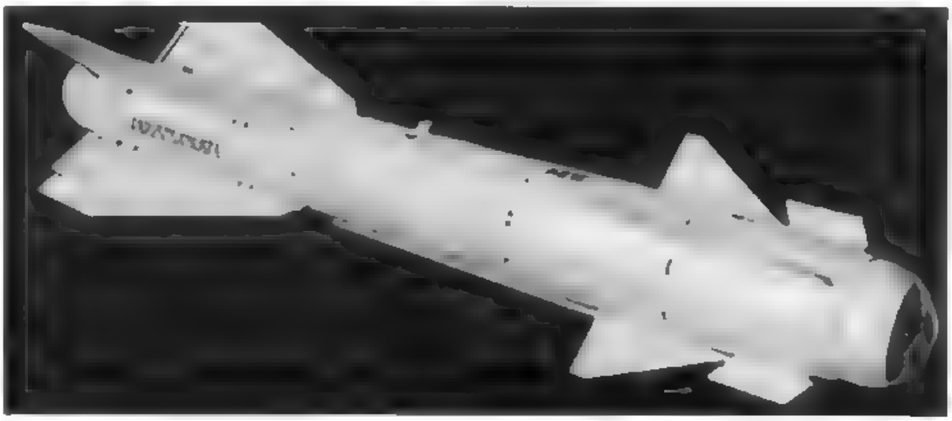
As mentioned in Chapter 1, OKB-293 founded by Matus Ruvimovich Bisnovat specialised in air-to-surface missiles at the start of its career. Later, however, the enterprise that changed its name to GMKB Vympel in 1967 became the Soviet Union's top authority in air-to-air missiles of all classes Thus the development of the Kh-29 air-to-surface missile in the late 1970s was something of a 'return of the prodigal son', but on a new technological level. Also, the company was now facing strong competition in this field from the specialised Zvezda OKB

Kh-29 air-to-surface missile

The Kh-29 missile is designed for annihilating tough ground and maritime targets, such as hardened aircraft shelters (HASs), concrete runways, major bridges and other structures (dams and the like) and large ships. To suit the mission it is equipped with the largest warhead among the ASMs carried by tactical aircraft – an impressive 320 kg (705 lb). To further increase its lethality the Kh-29's control system is programmed in such a way that the missile pulls up into a climb immediately before the target in order to dive down on it; this gives a more advantageous trajectory in the event of a low-altitude launch

The Kh-29 shares the aerodynamic and structural layout of the R-60 AAM developed by the same OKB (that is, a canard layout with cruciform fins and rudders, plus destabilisers ahead of the rudders) but is very much larger. It looks like an overgrown R-60 and is characterised by a large body diameter. Unlike the R-60, the large wings are pro-





Top right. On the laser-guided Kh-29L, the leading edges of the rudders protrude above the sharply tapered adapter between the rudder module and the narrow 'beak' of the seeker head carrying the trapezoidal destabilisers.

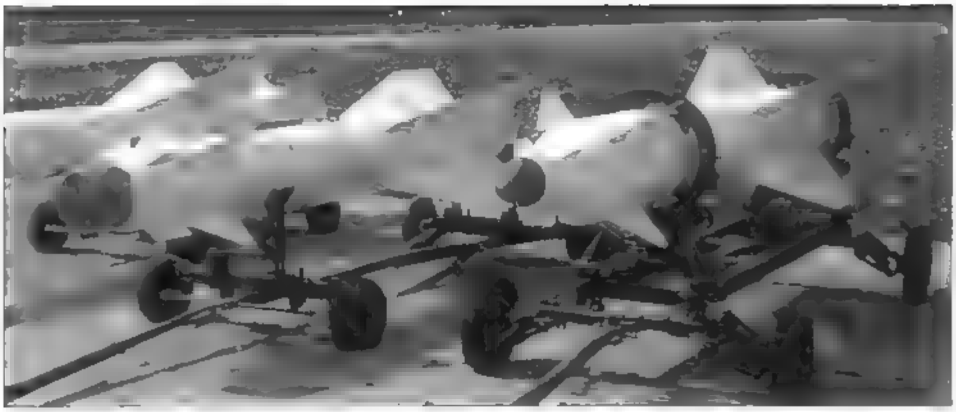
Above right: The TV-guided Kh-29T has a constant-diameter body with a hemispherical nose and differently shaped destabilisers.

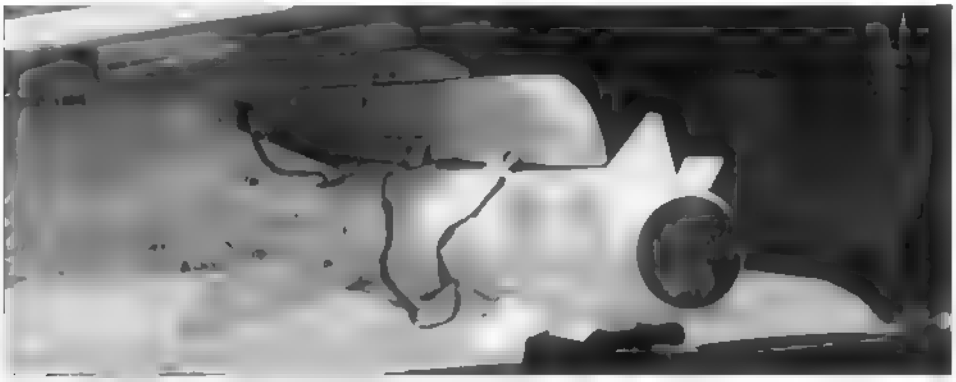
Right: The Kh-29TE differs in having a higher-powered rocket motor.

vided with inset ailerons. The missile is powered by a solid-fuel rocket motor housed in the rear body section.

The foremost body section ahead of the rudders houses the seeker head, its shape differs according to the type of guidance system used, and so does the shape of the destabilisers. The missile is available in three versions. The laser-guided Kh-29L (*izdeliye* 64L) features a semi-active seeker head with a small hemispherical window at the tip of a long conical fairing – a regular anteater's snout. The seeker head exhibits enhanced resistance to jamming and requires the aircraft to be equipped with a built-in or podded laser target designator; target acquisition takes place while the missile is still on the pylon. Apart from the Soviet Union, the Kh-29L was supplied to a number of 'friendly nations'. Iraq used these missiles successfully in the war with Iran in 1980-88: the missiles were fired by MiG-23BN and Dassault Mirage F1EQ-200 fighter-bombers equipped with French laser designators.

The TV-guided Kh-29T (*izdeliye* 64T) has a shorter, almost hemispherical nose incorporating a larger circular window. Working in conjunction with the Kaira laser rangefinder/marked target seeker or a similar system, the missile's seeker head transmits a



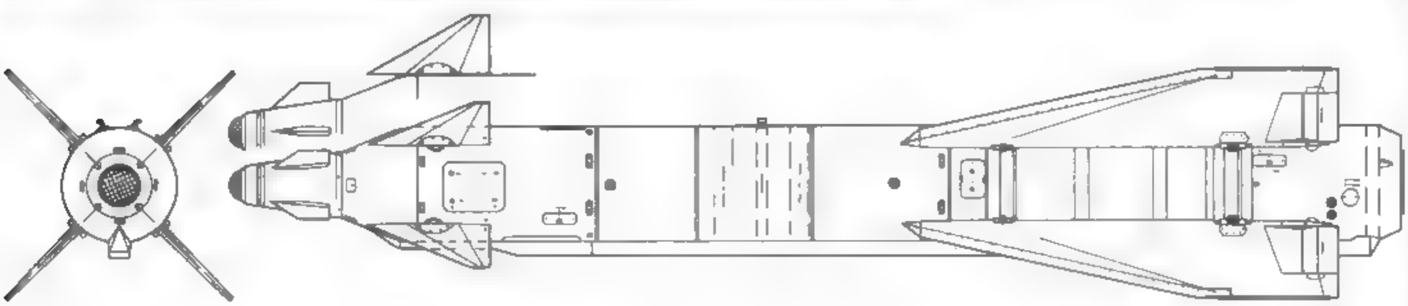


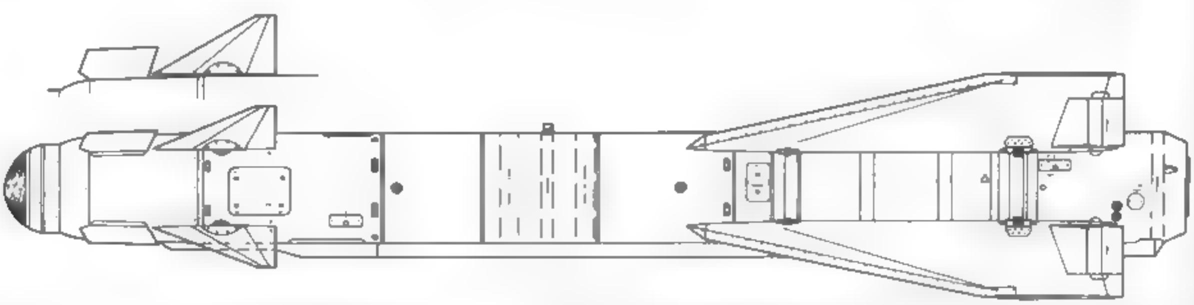
Top left: Two versions of the Kh-29 together; the missiles are obviously dummies, being devoid of markings. Note the different design of the dollies.

Above left: A Kh-29T on an AKU-58M ejector rack under the starboard wing of the fifth MiG-29M prototype ('155 Blue').

Left: This Kh-29T suspended under a Su-30 is an inert training round.

Below: The Kh-29L and Kh-29T. The scrap views show the shape of the rudders and destabilisers.





Right: An orange and white Kh-29T flanked by a Kh-31P and a dummy R-77 under the wing of MiG-29M '155 Blue' at Zhukovskiy during one of the Moscow airshows.

'bomb's eye view' to a cathode-ray tube (CRT) display in the aircraft's cockpit. Again, target acquisition takes place while the missile is still on the pylon and the aircraft is able to manoeuvre vigorously immediately after firing the missile

A sub-variant of the Kh-29T designated Kh-29TE features a longer-burn rocket motor increasing the maximum 'kill' range to 20-30 km (12 4-18 6 miles) The minimum launch altitude remains the same at 200 m (660 ft), while maximum launch altitude is increased to 10,000 m (32,810 ft)

The Kh-29 was introduced into the Soviet Air Force inventory in 1980 as a weapon for the tactical aviation arm For the sake of convenience its specifications are included in the final table of this chapter together with OKB-16's missiles

The Air-to-Surface Missiles of MKB Raduga

The OKB-16 design bureau (now called MKB *Raduga*, 'Rainbow' Machinery Design Bureau) originally specialised mainly in unguided rockets. One of its more modern products, the S-25 heavy unguided rocket, subsequently evolved into the S-25L laser-guided missile which is described together with the unguided version in Chapter 3

Kh-55 cruise missile

In the early 1980s the Soviet Air Force's strategic bomber arm was bolstered by the addition of a new-generation missile system designed for destroying a wide range of top-priority targets of strategic importance (nuclear weapon depots, military bases, major transport hubs and the like) whose precise geographical co-ordinates are known The system comprises the Tu-95MS *Bear-H* missile strike aircraft, a complement of Kh-55 cruise missiles featuring an autonomous gyro-inertial navigation system and a terrain-following feature, and other equipment. Digital maps featuring the individual targets for the missiles are stored in the aircraft's on-board data recording system and downloaded to each missile before launch

Above right: This Kh-55 cruise missile is a Kh-55U training round duly marked 'Uchebnaya'. The stowed wings are just discernible in this view.

Right. A Kh-55SM extended-range cruise missile with conformal fuel tanks sits with the wings and tail surfaces deployed beside a Tu-160 bomber

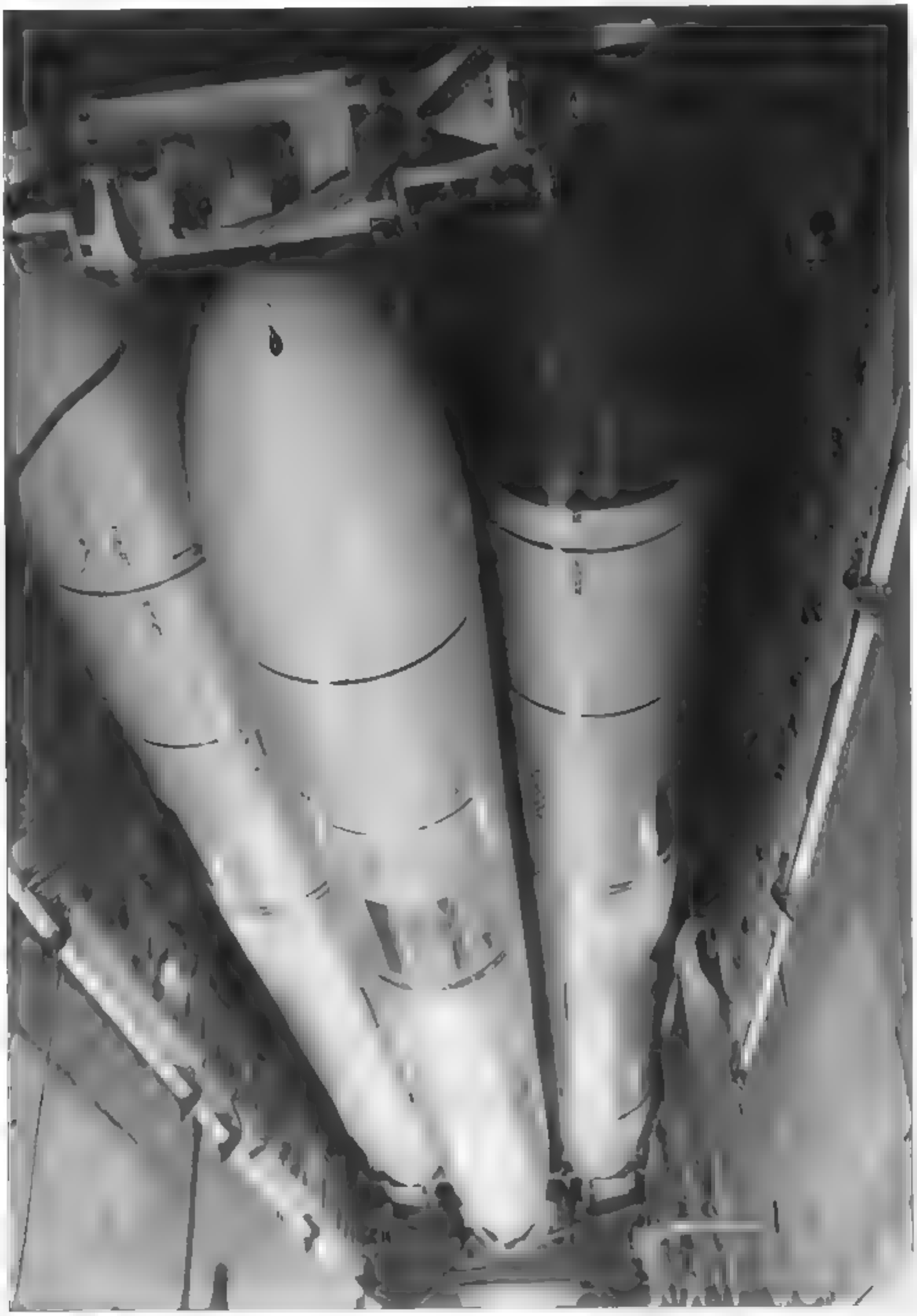
Left: Another Kh-55SM is prepared for loading into the forward bomb bay of a Tu-160. The aircraft can carry up to twelve such missiles on two rotary launchers. Note the cloth cover.

Two sub-variants of the *Bear-H* existed initially. On the Tu-95MS-6 up to six Kh-55 missiles are carried internally on an MKU6-5 rotary launcher (***mnogopozitsionnaya katapool'tnaya oostanovka*** – lit. 'multi-position ejector unit') closed by the clamshell weapons bay doors. The Tu-95MS-16 could carry an additional ten missiles on four pylons under the wings (three on each inboard pylon and two on each outboard one) but these pylons were later removed in keeping with offensive arms reduction treaties limiting the number of warheads each aircraft is allowed to carry.

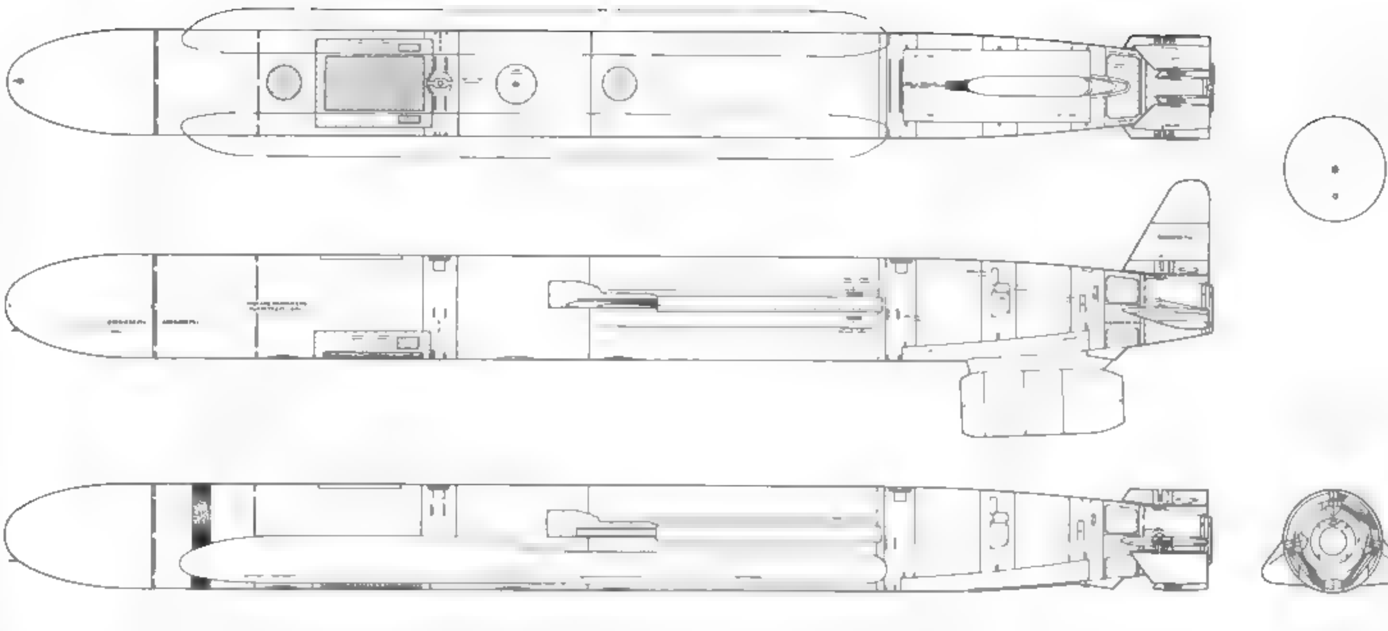
The Kh-55 is a subsonic aerial vehicle with folding wings and tail surfaces. The mid-set, high aspect ratio unswept wings are stowed inside the fuselage for ground handling and when the missile is on the launcher (or pylon), pivoting forward automatically when the missile is well clear of the aircraft. To save space and avoid increasing the fuselage diameter the port and starboard wings are stowed in two parallel planes above one another, and this lop-sided arrangement remains when they are deployed. The wings are one-piece glassfibre composite structures lacking control surfaces. Extension is by means of a pyrotechnically-actuated mechanism with a synchronisation feature preventing asymmetrical deployment.

The metal fuselage is built in three sections. Section 1 features a large dielectric radome of parabolic shape for the radar seeker head. The forward bay of Section 2 (the centre fuselage) incorporates a heat-insulated compartment for the nuclear warhead. Further aft, in the centre portion, is the wing stowage bay, with the fuel tanks above it. The sides of this bay are closed by spring-loaded doors which close again after the wings deploy to ensure a smooth airflow.

The fuel tanks are filled with degassed fuel to preclude an excessive rise in internal pressure at high altitude which might cause damage to the tanks. This also serves to reduce the water content in the fuel and hence the risk of having the fuel filters becoming clogged with ice at low ambient temperatures. The rear bay of Section 2 houses the retracted engine and its pantographic mount flanked by more fuel tanks. The aperture below the engine is closed by



Three Kh-55s out of six suspended on the MKU6-5 rotary launcher of a Tu-95MS-6. The black-tipped example on the right is clearly marked as a training round.



Top to bottom: Lower view of a Kh-55SM with conformal tanks in pre-launch configuration; a Kh-55 in cruise configuration; and a side view of a Kh-55SM in pre-launch configuration

double doors which open only when the engine is in transit

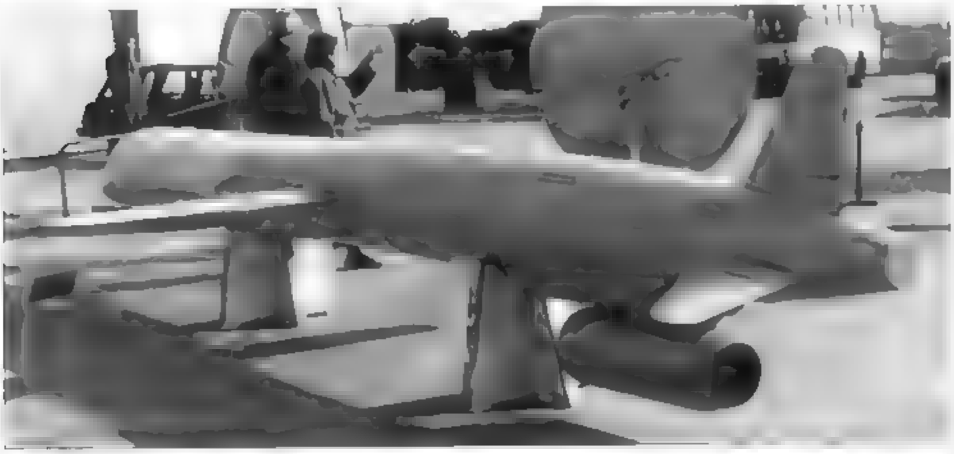
Section 3 (the rear fuselage) accommodates electric equipment and the self-contained fin/stabilator actuation system. It terminates in a collapsible tailcone which is extended at the moment of launch concurrently with wing/tail surface deployment to reduce drag and improve control efficiency The tailcone consists of a telescopic boom and a set of concentric rings held together by fabric strips ('the scales and skin of a dragon's tail'?)

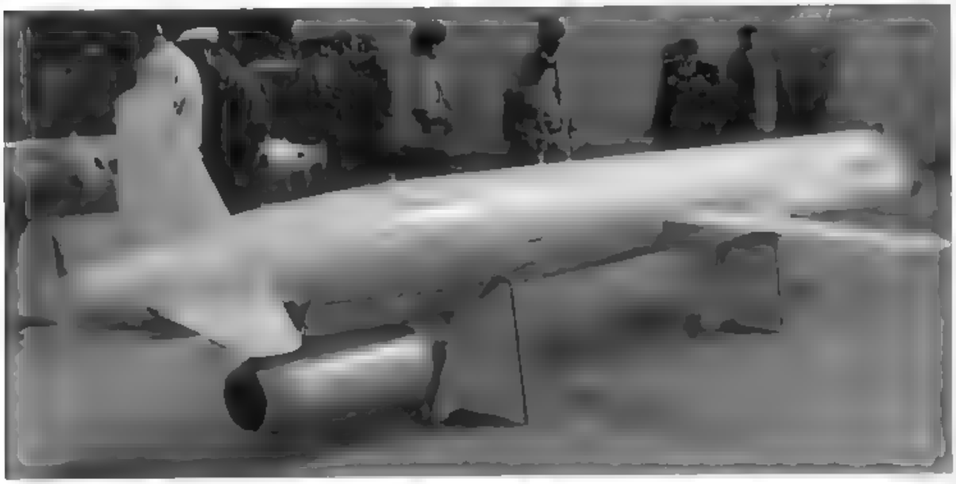
The all-movable fin and stabilators are double-hinged glassfibre composite structures similar in design to the wings, they lie flat against the rear fuselage sides and are similarly deployed by a pyrotechnically-actuated mechanism, the stabilators having strong anhedral when deployed

The specially developed disposable turbofan rated at 300-350-kgp (660-770 lbst) is housed in a close-fitting cylindrical nacelle stowed inside the centre fuselage and deployed on a short pylon with a pantographic mechanism immediately before launch. The engine's systems are com-

Tu-160 '342 Blue' (c/n 84704217), the one that participated in numerous airshows, launches a red-painted Kh-55 instrumented test round. Note that the missile's engine and tail surfaces are already deployed but the wings are still stowed

Left: A mock-up of a Kh-65SE cruise missile displayed at one of the MAKS airshows. This view shows the modified forward fuselage of quasi-triangular section with 'cheek pouches'.





Below left and bottom: 'The dragon and his tail. These views illustrate well the 'scaly' extended tailcone and the deployed turbofan with the bay doors partially open

pletely self-contained and maintenance-free The engine features full authority digital engine controls (FADEC)

The engine swings out of its centre fuselage compartment when the missile is still on the launcher; it is started after separation. At a safe distance from the aircraft the wings and tail surfaces unfold and the Kh-55 commences autonomous flight along the pre-programmed route to the target To avoid detection and destruction by enemy air the Kh-55 flies at 40-110 m (130-360 ft), making use of the terrain-following feature

Apart from the subsonic Tu-95MS, the missile is carried by the Tu-160 *Blackjack* supersonic strategic missile strike aircraft; the latter's weapons complement is twelve Kh-55s on two MKU6-5 rotary launchers The first operational Tu-160 unit (the 184th Guards Heavy Bomber Regiment at Priluki AB, the Ukraine) began practice launches of Kh-55s as early as 1987 – that is, before the *Blackjack*'s US counterpart, the Rockwell International B 1B, started cruise missile launches. In 1992 the Russian government terminated production of the Tu-95MS and Tu-160 for both political and economic reasons, recently, however, production of the *Blackjack* has resumed on a small scale

The Kh-55 is also available in ground- and sea-launched versions. To extend its reach the missile can be fitted with conformal tanks of complex shape low on the forward fuselage sides, the long-range version is sometimes referred to as the Kh-55SM

Kh-65SE anti-shipping cruise missile

The Kh-55 evolved into a long-range anti-shipping strike version designated Kh-65SE to be carried by the Tu-22M3 and other aircraft. Outwardly it differs from the Kh-55 in having a reshaped forward fuselage housing a shaped-charge armour-piercing/high-explosive warhead instead of a nuclear charge

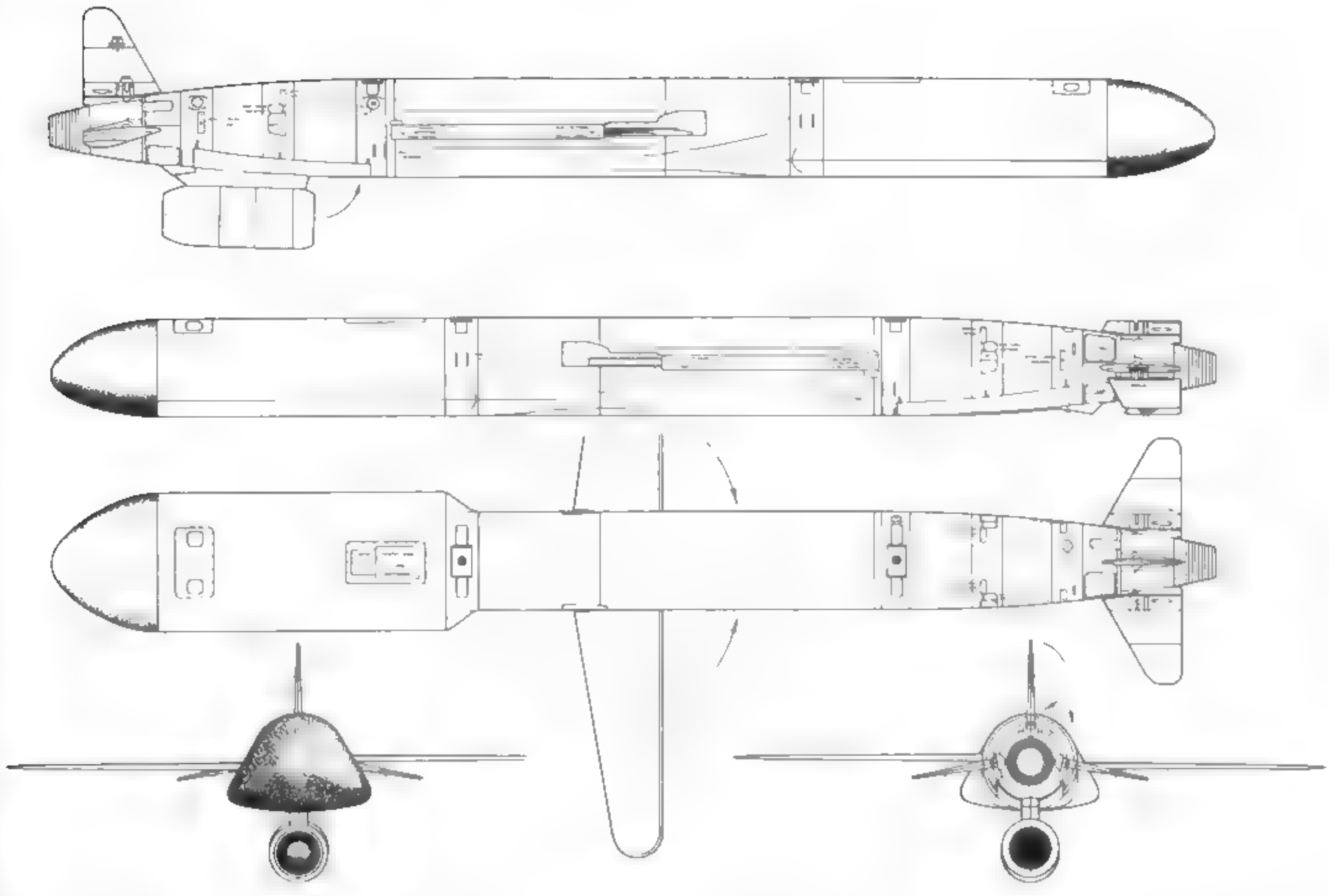
The missile utilises an INS at the cruise stage, switching to active radar homing for terminal guidance. Like the Kh-55, after launch it follows a pre-programmed route but the flight altitude is lower (10-40 m/33-130 ft), again, the Kh-65SE has a terrain-following feature allowing it to circumnavigate major obstacles

Kh-41 Moskit (3M80, ASM-MSS) anti-shipping missile

In 1980 MKB Raduga brought out the Kh-41 anti-shipping missile designed for use both by surface ships and as an air-launched weapon carried by the Su-27K (Su-33) shipboard fighter. The missile has a conventional layout with folding cruciform fins and rudders. Like the Kh-31, it features an integrated powerplant comprising a solid-fuel booster and a ramjet sustainer; the booster is ejected from the jetpipe, once the ramjet lights up

The missile's appearance is best described as 'a big, fat Kh-31'. The large ogival nose radome houses a two-mode active/passive radar seeker head with high ECM resistance. Together with the INS it ensures a high 'kill' probability even in an ECM environment. The warhead occupies the rest of the forward body section aft of the seeker head

Four relatively small semi-circular supersonic air intakes for the sustainer are located on the body's centre section in two perpendicular planes (that is, the same planes as the fins and rudders); each intake features a half-cone centrebody optimising the airflow The four low aspect ratio delta fins set at 45° to the horizontal plane are located a short way aft of the intakes, the upper fins fold down through 90° and the lower ones up through 90° for ground handling and carriage on the pylon. The centre body section



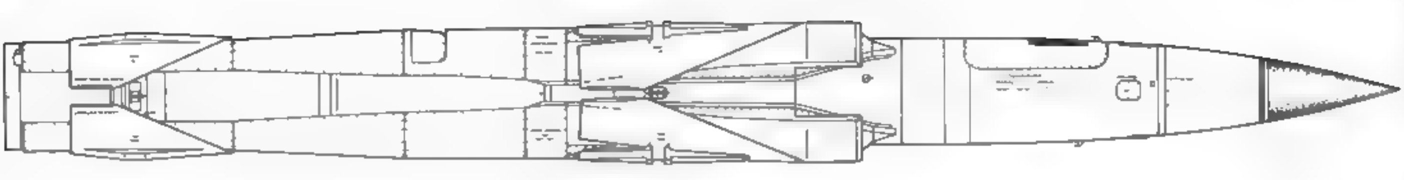
Five views of the Kh-65SE. The rear view shows how the double-jointed fin folds; the stabilators fold in the same fashion. The tailcone is shown in extended position in all views.

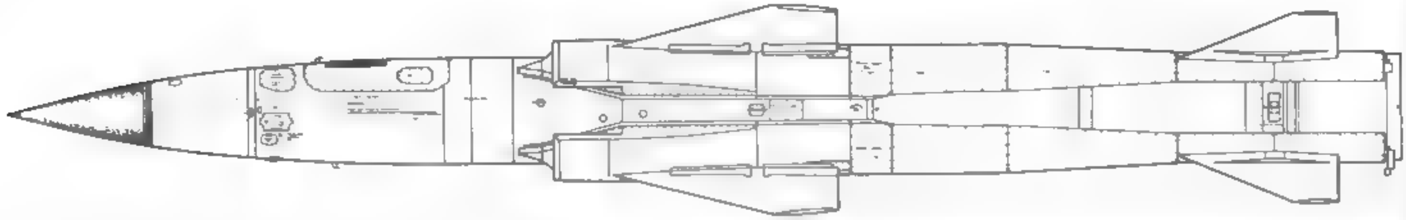
accommodates the fuel tanks, the Kh-41 utilises the so-called ampoule method – prefabricated canisters filled with a long-life liquid fuel are installed by the manufacturing plant. The folding all-movable cruciform rudders are installed on the rear body section in the same planes as the fins.

Due to its large size and weight the Kh-41 can only be carried on a special pylon on the Su-27K's centreline, fitting neatly into the tunnel between the air intake trunks. The fins and rudders unfold and the booster fires after the missile falls clear of the aircraft. When the target is 250 km (155 miles) away, the missile accelerates to Mach 3 in cruise mode, approximately 50 km (31 miles) out it descends to about 20 m (65 ft) and then to just 7 m (23 ft) above the water to escape detection by the ship's air defences. Alternatively, the Kh-41 descends to a cruise altitude of 20 m immediately after launch at a range of up to 150 km (93 miles) and carries on at Mach 2.1 before descending to 7 m shortly before impact. In both cases the missile is capable of making abrupt high-G manoeuvres to dodge the enemy air defences.

Until 1994, when it was unveiled to numerous Western aviation experts at the FIDAE'94 airshow in Santiago de Chile, the Kh-41 rated as top secret. Incidentally, the true designation remained classified for a few more years; originally the missile was known to the world as the ASM-MSS (supposedly standing for 'air-to-surface missile – missile supersonique'). The world's most authoritative reference books on military hardware describe this weapons system as having unmatched capabilities. Indeed, the

A Kh-41 (ASM-MSS) during its first public appearance on Russian soil at the MAKS-95 airshow. Note how the supersonic air intakes with half-cones stand apart from the fuselage and how the fins and rudders fold.

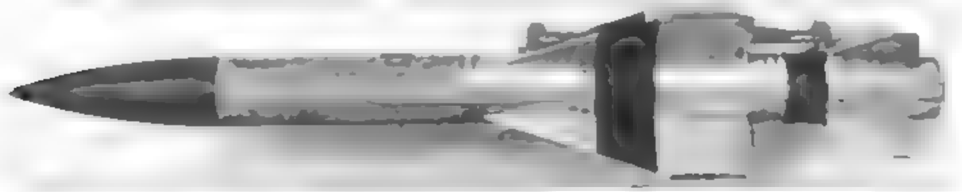


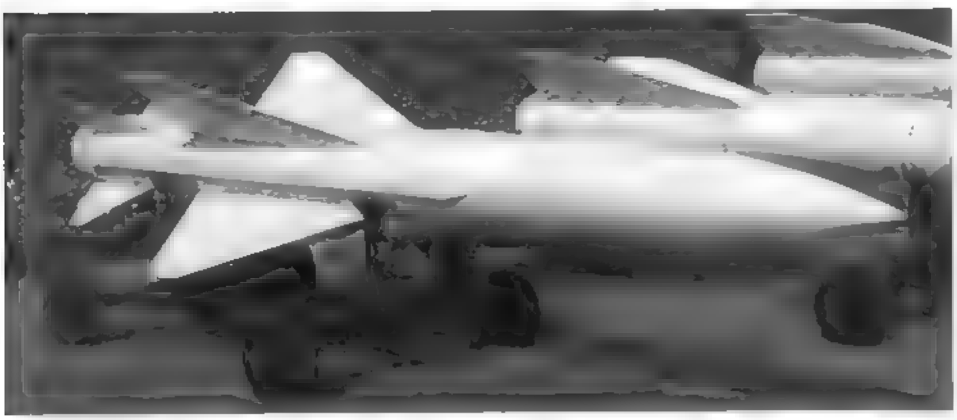


Above: The Kh-41 (3M80, or ASM-MSS) with the fins and rudders folded and deployed

Kh-41 is the world's only missile capable of doing Mach 2.5 at an altitude of just 10 m (33 ft) or so, making it hard to detect, much less shoot down. Due to its substantial kinetic energy the big, heavy missile can punch through the hull of virtually any ship, exploding inside to start a massive fire.

The missile entered Soviet Navy service in 1984 – initially in a surface-to-surface version designated 3M80 and named *Moskit* (Mosquito); in tube-launched form it was carried by ***Molniya*** (Lightning) class fast missile boats, ***Samoom*** (Simoom) class hovercraft and *Sovremennyy* (Modern) class destroyers. (Note: The names mentioned here are the Soviet names of the actual first ships in the classes, **not** NATO codenames like 'Juliet class submarine'.) The air-launched version designated Kh-41 followed later as a weapon for the Su-27K, the Soviet/Russian Navy's sole operational conventional take-off and landing fighter type.





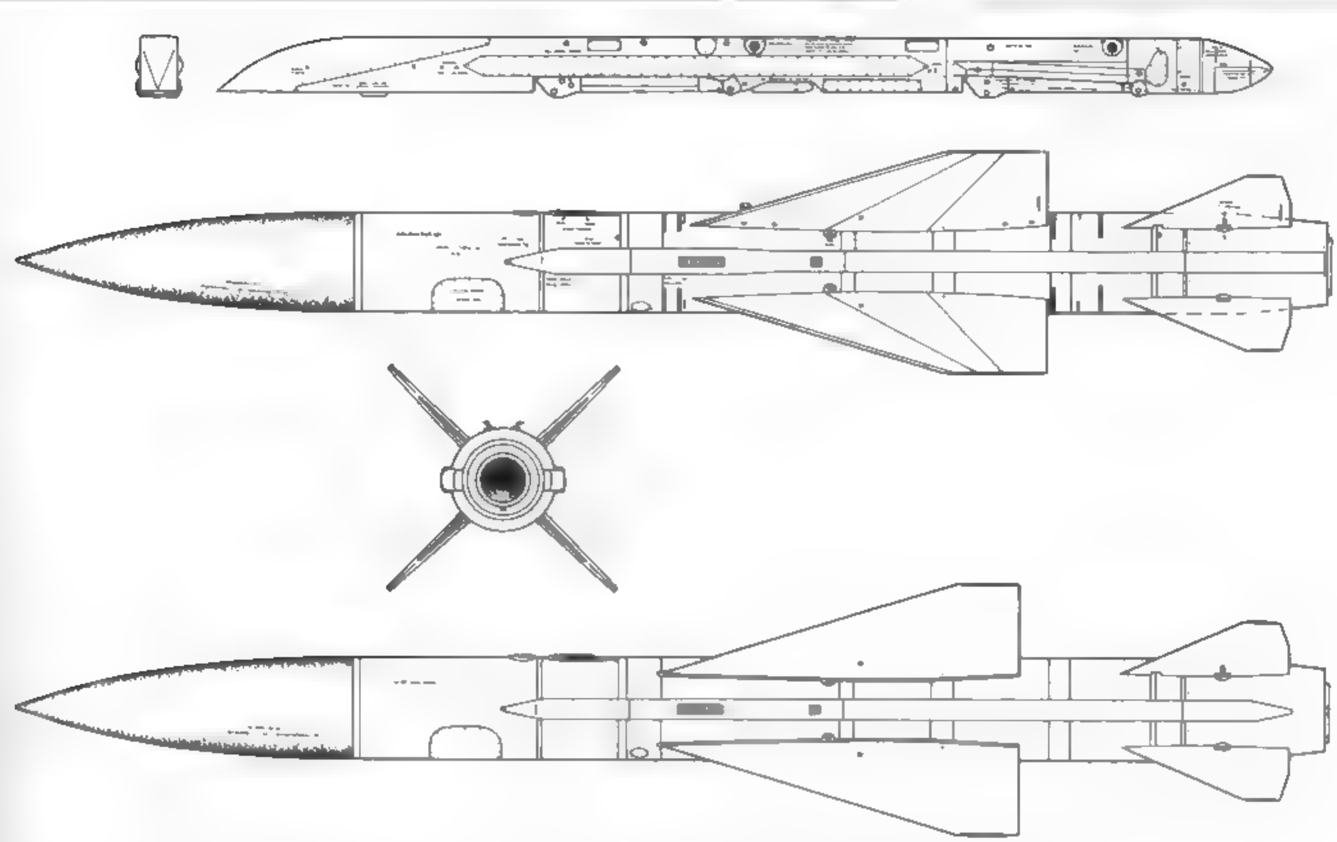
Kh-58 and Kh-58U anti-radiation missiles (*Izdeliye* 112)

The Kh-58 anti-radiation missile (*izdeliye* 112) is designed for use against ground radars operating in various wavebands in continuous emission or pulse modes. Being a follow-on to the Kh-28, KSR-5P and other ARMs, it has a similar aerodynamic and structural layout but, like most air-launched missiles, the Kh-58 is powered by a solid-fuel rocket motor.

The use of solid-fuel rocket motors eliminates virtually all maintenance operations associated with liquid-propellant rocket motors, most importantly, there is no need to handle hazardous fuel components. Also, solid-fuel rocket motors deliver much higher thrust in relation to their weight, which allows the missile to be made smaller and lighter. On the minus side, solid-fuel rocket motors have a short operation time to burnout, a shortcoming that is alleviated on air-to-surface missiles by using a ballistic trajectory. In cruise flight the missile climbs as it moves towards the target and the climb continues after burnout as the missile coasts; this makes it possible to achieve the desired range.

Top left: An inert test round of the Kh-58U anti-radiation missile on a lifting trapeze hooked up to the attachment lugs.

Left and above left: A mock-up of the Kh-58U displayed at an air fest. A curious feature of the Kh-58 is the two lateral conduits instead of one ventral one.

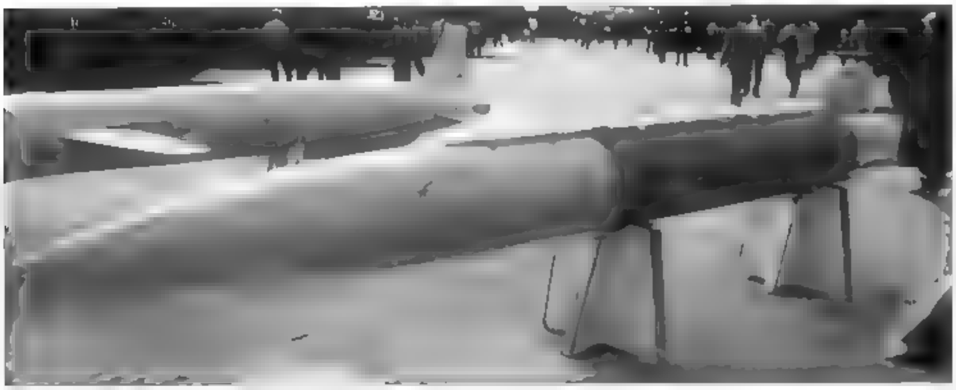


Top to bottom. Front and side views of the AKU-58 ejector rack, side and rear views of the Kh-58, and a side view of the Kh-58U.

The following tables give the specifications of the missiles of MKB Raduga.

	Kh-55	**Kh-65SE**	**Kh-41 (ASM-MSS)**	**Kh-58E**
Codename				
US	AS-15A	none	none	AS-11
NATO (ASCC)	*Kent*	none	none	*Kilter*
Service entry	1984		1984	n.a.
Length overall	5.88 m (19 ft 3 1/2 in)	6.04 m (19 ft 9 13/16 in)	9.745 m (31 ft 11 21/32 in)	4.8 m (15 ft 8 31/32 in)
Wing span	0/3.1 m (10 ft 2 in)*	0/3.1 m (10 ft 2 in)*	2.1 m (6 ft 10 11/16 in)	1.7 m (5 ft 6 15/16 in)
Body diameter	0.514 m (1 ft 8 1/4 in)	0.514 m (1 ft 8 1/4 in)	0.76 m (2 ft 5 15/16 in)	0.38 m (1 ft 2 31/32 in)
Launch weight, kg (lb)	600 (1,430)	1,250 (2,755)	3,950 (8,710)	650 (1,430)
Warhead weight, kg (lb)	n.a.	410 (900)	300 (660)	149 (328)
Launch range, km (miles)	600 (370)	280 (174)	250 (155)	120 (74.5)
Launch altitude, m (ft)	700-10,000 (2,300-32,810)	700-12,000 (2,300-39,370)	n.a.	100-10,000 (3,280-32,810)
Flight altitude, m (ft)	40-110 (130-360)	10-40 (33-130)	down to 7 (23)	variable
Speed Mach number	0.8	0.8	2.1-3.0	3.6
Powerplant	Turbofan	Turbofan	Solid-fuel rocket motor + ramjet	Solid-fuel rocket motor
Missile platform	Tu-95MS Tu-160 Tu-95M-55	Tu-22M3	Su-27K	Su-17M3/M4 Su-24 Su-25T MiG-25BM

* Wings folded/deployed.



Left and below left: A cutaway instructional round of the Kh-15 wingless air-to-surface missile on display at Zhukovskiy. The Kh-15 is quite a large weapon.

Bottom left: This view shows the three short fins located at 120° to each other Since this is effectively a mock-up, the nozzle is blanked off by a round plate.

The Kh-58's high-explosive warhead is placed close to the centre of gravity and is detonated by a Sych (Barn Owl) radio proximity fuse whose aerials are located around the warhead bay ahead and aft of the wings The rocket motor is housed in the rear body section which is quite long, this section also houses the actuators of the all-movable cruciform rudders. The trapezoidal cruciform rudders are deflected differentially for controlling the missile in all directions of flight The trapezoidal cruciform fins with a span of 1.17 m (3 ft 10 in) lack control surfaces and are set at 45° to the horizontal plane. The Kh-58 is the first missile of MKB Raduga to feature cruciform fins

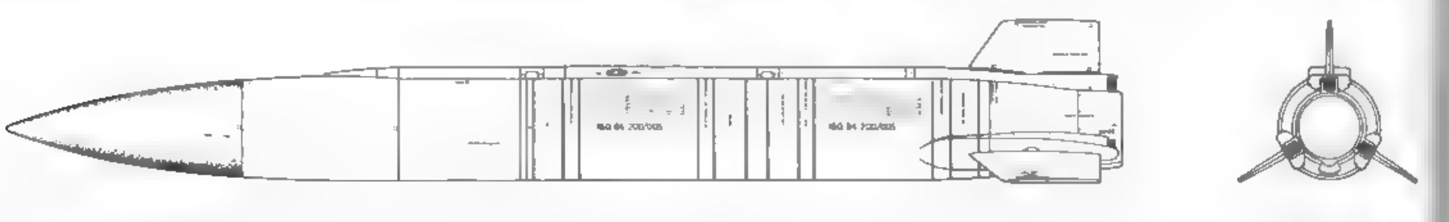
The missile is carried on the specially developed AKU-58 ejector rack and has found use on the Su-17M4, Su-24M, Su-25T and MiG-25BM, among other things; the latter aircraft is a specialised 'Wild Weasel' SEAD version To feed target data to the missile while it is still on the wing the aircraft needs to be fitted with the V'yooga or *Fantasmagoriya* (Phantasm) radar detection/guidance equipment in built-in or podded form

Later, a modified version designated Kh-58U was brought out, differing in having an impact fuse and new fins. The fins have a higher aspect ratio and a longer span of 1 31 m (4 ft 3$\frac{37}{64}$ in) – quite simply, less is lopped off a theoretical pure delta shape. Additionally, the fins are moved forward; this together with their new shape, improves the missile's ballistics and makes for longer range The same purpose is also served by the more powerful rocket motor

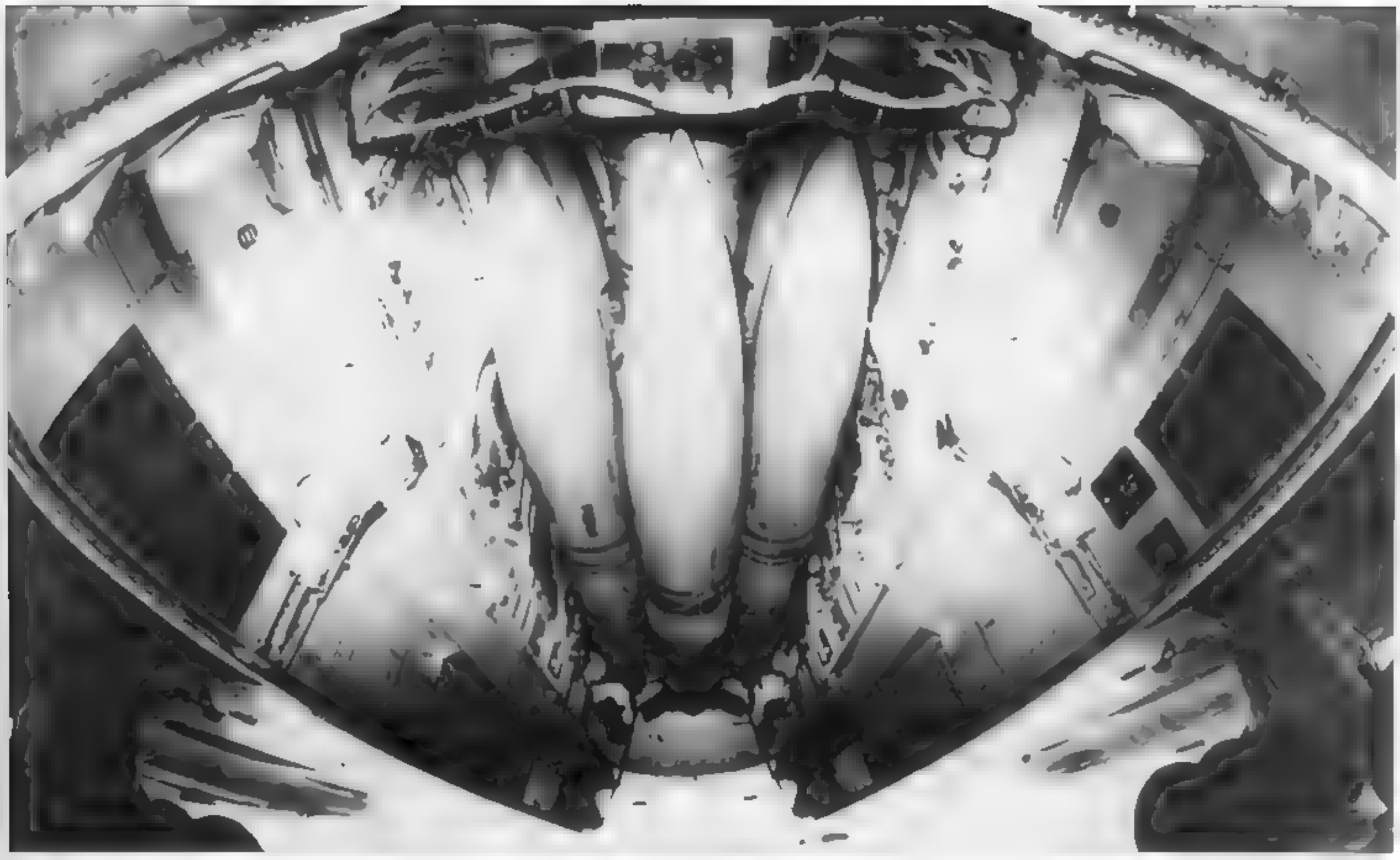
Kh-15 air-to-surface missile

Developed as a successor to the obsolete Kh-22 and KSR-5 missiles, the Kh-15 is a new-generation wingless missile with a solid-fuel rocket motor utilising a ballistic trajectory as a means of extending range. The missile's airframe comprises a body and all-movable tail surfaces The body layout is similar to that of the Kh-58, except that the warhead is moved forward to a place immediately aft of the seeker head in order to obtain the correct CG position. The tail unit consists of a vertical fin and two stabilators set at 120° with respect to the fin and each other; all three tail surfaces are identical. The stabilator span is 0 92 m (3 ft 0$\frac{7}{32}$ in)

After launch at a maximum range of 150 km (93 miles) the missile goes ballistic, accelerating to Mach 5 and entering the stratosphere with an apogee at up to 40 km



The Kh-15 missile; the rear view illustrates an engineless training round with a blanked-off nozzle.



Above: A look inside the bomb bay of a Tu-22M3, showing six inert Kh-15s on an MKU6-5 rotary launcher

(131,230 ft) The flight trajectory is formed by the aircraft's targeting system to suit the applicable launch range while the missile is stil on the launcher

Trials of the Kh-15 commenced in 1988 and were concluded by the go-ahead for production and service. The missile is carried internally on MKU6-5 rotary launchers by the Tu-22M3 medium-range bomber, the Tu-95MS-6 and the Tu-160 strategic missile strike aircraft; the latter type has a complement of twelve Kh-15s, while the other two can carry six each

The Kh-15 is designed for destroying large-area targets and equipped with a nuclear warhead. Therefore it features an INS which guides the missile to the target, using pre-entered co-ordinates. In contrast to other air-to-surface missiles with an S suffix to the designation (for ***spetsboyepripahs*** – 'special munition'), the Kh-15S has a conventional shaped-charge/high-explosive warhead, being an anti-shipping missile It is designed for destroying surface ships with a high radar signature and known co-ordinates, hence it is equipped with an active radar seeker head for terminal guidance

The Kh-15P with a passive radar seeker head is an ARM designed for use against various types of radars

Kh-59 Ovod air-to-surface missile

The Kh-59 air-to-surface missile is part of the *Ovod* (Gadfly) weapons system which also includes the Su-24M tactical bomber and the APK-9 guidance system pod (*apparatoora peredahchi komahnd* – command link equipment) The missile is intended for use against pinpoint ground targets (or small surface ships) with known co-ordinates not far behind the frontlines

The Kh-59 is one of the few tactical missiles developed by MKB Raduga, and the company had no previous experience with weapons in this category to fall back on

Right: A Kh-59M missile with a protective cover over the seeker head window in the static park of one of the Moscow airshows. Th M version can be readily identified by the turbofan engine.

Above: The Kh-59M makes an interesting comparison with the Kh-29T under the wing of a Su30. Note the cover closing the engine intake to prevent windmilling until the missile is launched and the folded position of the stabilising canard foreplanes.

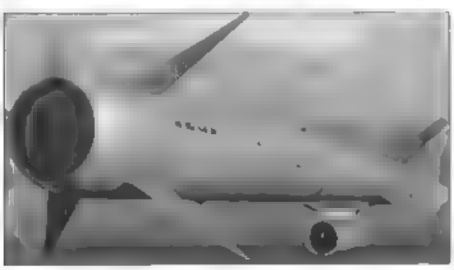
Hence the missile is very different in layout and detail design from other missiles created by the enterprise. It is optimised for high subsonic speeds. The missile has a canard layout with fixed cruciform foreplanes and cruciform wings mounted well aft. The body is built in six sections, the foremost of which houses the seeker head and carries the swept canards; the latter are folded backwards for ground handling and when the missile is on the wing, popping up after launch

Section 2 accommodates the avionics modules of the seeker head and other guidance system components, followed by the generator pack, radio altimeter and autopilot in Section 3. Section 4 houses the shaped-charge/high-explosive warhead

Section 5 houses a solid-fuel rocket motor with twin lateral nozzles and incorporates wing attachment fittings, to this is attached the tail section accommodating the control surface actuators, the TV command guidance system transceiver and other equipment. A solid-fuel rocket booster stage is mated to the rear end of this tail section, it is jettisoned after accelerating the missile

The trapezoidal wings have inset ailerons located at the root sections of the trailing edges; these are deflected differentially for controlling the missile in all directions of flight. A ventral wiring conduit runs the full length of the missile

The Kh-59 is manufactured in two versions with different guidance systems,



Above and right: An artist's impression and a display model of the Kh-59M in launch configuration, showing the deployed canards and the solid-fuel rocket booster scabbed on at the rear; it is jettisoned after the turbofan fires up. The cruise engine is mounted well aft for CG reasons.

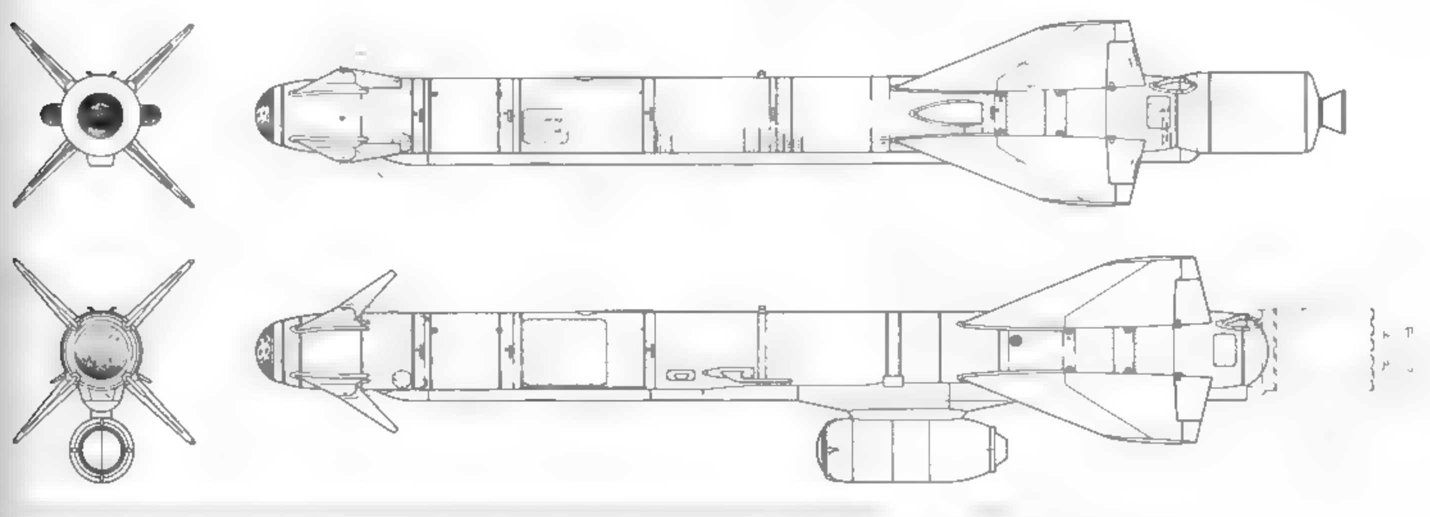
	Kh-15S	Kh-59	Kh-59M	Kh-29L/T
Codename				
US	AS-16	AS-13	AS-18	AS-14
NATO (ASCC)	*Kickback*	*Kingbolt*	*Kazoo*	*Kegde*
Service entry	n.a.	n.a.	n.a.	1980
Length overall	4.78 m (15 ft 8 3/16 in)	5.37 m (17 ft 7 13/32 in)	5.69 m (18 ft 8 in)	3 875/3.9 m (12 ft 8 9/16 in; 12 ft 9 9/16 in)
Wing span	0	1.3 m (4 ft 3 3/16 in)	1.3 m (4 ft 3 3/16 in)	1.07 m (3 ft 6 1/8 in)
Body diameter	0.455 m (1 ft 5 29/32 in)	0.38 m (1 ft 2 31/32 in)	0.38 m (1 ft 2 31/32 in)	0.38 m (1 ft 2 31/32 in)
Launch weight, kg (lb)	1,200 (2,645)	850 (1,870)	920 (2,030)	660/680 (1,455/1,500)
Warhead weight, kg (lb)	150 (330)	320 (705)	320 (705)	320 (705)
Launch range, km (miles)	150 (93)	40 (25)	115 (71)	8-10 (5-6.2)
Launch altitude, m (ft)	300-22,000 (9,840-72,180)	100-5,000 (330-1,640)	100-5,000 (330-1,640)	200-5,000 (660-1,640)
Flight altitude, m (ft)	Up to 40,000 (131,280)	100-1,000 (330-3,280)	7-10 (23-33)	variable
Speed, km/h (mph)	Mach 5.0	1,000 (621)	860 (534)	n.a.
Powerplant	Solid-fuel rocket motor	Solid-fuel rocket motor	RDK-300 turbofan	Solid-fuel rocket motor
Missile platform	Tu-95MS, Tu-160, Tu-22M3	Su-17M3, Su-24, Su-34	Su-17M3, Su-24, Su-34	Su-17M3/M4, Su-24M, Su-25T, Su-27M, Su-34, MiG-27M/K, MiG-29M

accordingly different targeting equipment has to be carried by the aircraft. The Kh-59T has a TV seeker head and a TV command guidance system, transmitting a 'bomb's eye view' to a TV screen in the Su-24M's cockpit after launch; the weapons systems operator controls the missile's flight by means of a mini-joystick until the seeker head achieves a lock-on, switching to homing mode.

The Kh-59L is a laser-guided weapon which requires the target to be illuminated by an airborne or man-portable laser designation. It also features an inertial navigation system that controls the missile's flight until the moment of lock-on.

Kh-59M/Kh-59ME Ovod-M air-to-surface missile

The Kh-59M is an upgraded version of the Kh-59 possessing considerably longer range – 115 km (71 miles) instead of 40 km (25 miles). To achieve this the solid-fuel rocket motor is substituted with a fuel-efficient RDK-300 turbofan installed in a non-



Top: Rear and side views of the Kh-59 Ovod; above: front and side views of the Kh-59M Ovod-M. Both missiles are in launch configuration.

retractable ventral nacelle The air intake s closed by a fairing that is jettisoned after launch, whereupon the engine is started by a cartridge starter

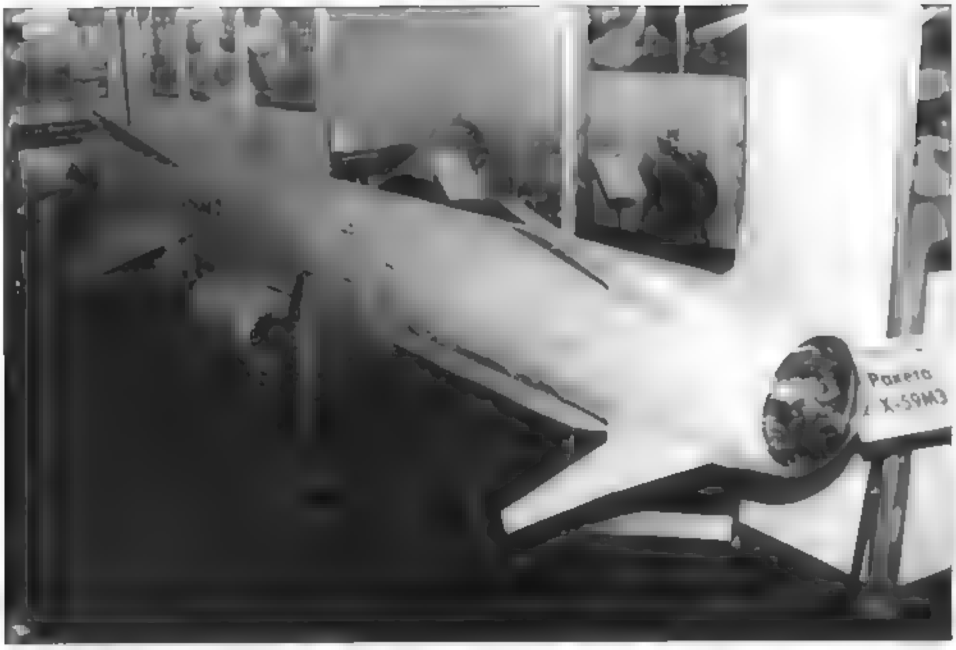
The former rocket motor bay is replaced by a longer subassembly housing the fuel tank, the fuel flow regulator and other equipment; the engine nacelle is attached to it from beneath. Due to the missile's greater length the wings are located further aft along the fuselage As with the Kh-59T, a solid-fuel rocket booster is attached to the rear end of the body

Again, the Kh-59M comes in both TV-guided and laser-guided versions. After launch the missile cruises at one of four preset stabilised flight levels – 100 m (330 ft) 200 m (660 ft), 600 m (1,970 ft) or 1,000 m (3,280 ft). When used as an anti-shipping missile the Kh-59M can be programmed to cruise 7 m (23 ft) above the water. An export version is designated Kh-59ME

The Su-24M can carry two Kh-59s or Kh-59Ms on underwing AKU-58 ejector racks

Kh-59MK Ovod-MK air-to-surface missile

The Kh-59MK differs from the Kh-59M in having an active radar seeker head This version is identifiable by a thicker forward body section terminating in a large parabolic radome



Above left: The Kh-59ME export version on display at one of the Moscow airshows. The TV seeker system is clearly visible through the glass [redacted].

Left: The Kh-59MK radar-0homing version at the same event, the radar seeker head has a bigger diameter than the missile's body.

Below: A Tu-22M3 in a rarely seen configuration with three Kh-22Ms featuring PMG seeker heads.

MOVING MUD: THE UNGUIDED ROCKETS

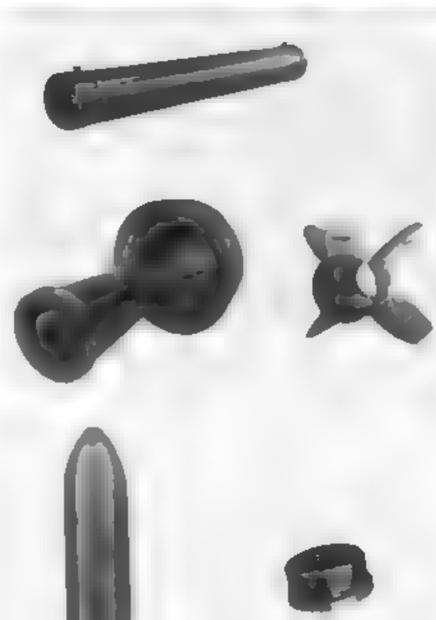
Back in 1921 the Gas Dynamics laboratory (GDL – *Ghazodinamicheskaya laboratoriya*) was established in the city then known as Petrograd (formerly St Petersburg, to be renamed Leningrad a few years later). Originally headed by N. Tikhomirov and subordinated to the Red Army's Chief of Armaments, it was tasked with research in the field of rocket weapons. In due course the GDL developed the first Soviet unguided rockets of 82 mm (3.22 in) and 132 mm (5.19 in) calibre and the associated launchers. The first official launches of RS-82 unguided rockets from a Tupolev I-4 biplane fighter equipped with six launch rails took place in 1932.

A while earlier, in the autumn of 1931, the Jet Propulsion Research Group (GIRD – *Grooppa izoocheniya reaktivnovo dvizheniya*) was set up in Moscow as a division of the Aviation & Chemical Industry Support Society (Osoaviakhim – *Obshchestvo sodeystviya aviahtsii i khimicheskoy promyshlennosti*). Originally GIRD was headed by Feliks A. Tsander, but less than a year later, in 1932, he was succeeded by the subsequently world-famous Sergey P. Korolyov. Under his guidance the group undertook development of unguided rockets and guided missiles with liquid-propellant rocket motors intended both for ground troops and for the Red Army Air Force; a stratospheric rocket was also under development.

In September 1933 the GDL and GIRD were amalgamated into the Jet Propulsion Research Institute (RNII – *Reaktivnyy naoochno-issledovatel'skiy institoot*) which took up residence at the premises of the Agricultural Machinery Institute in Moscow. (This was the 'root of all evil', explaining why enterprises manufacturing weapons were part of the Ministry of Agricultural Machinery framework in the early post-war years!) I. V. Kleymyonov was the institute's first Director; in subsequent years RNII's heads changed repeatedly as their predecessors were arrested during Stalin's purges. By 1941 the institute had become NII-3 – the Soviet Union's leading organisation responsible for rocket and missile development.

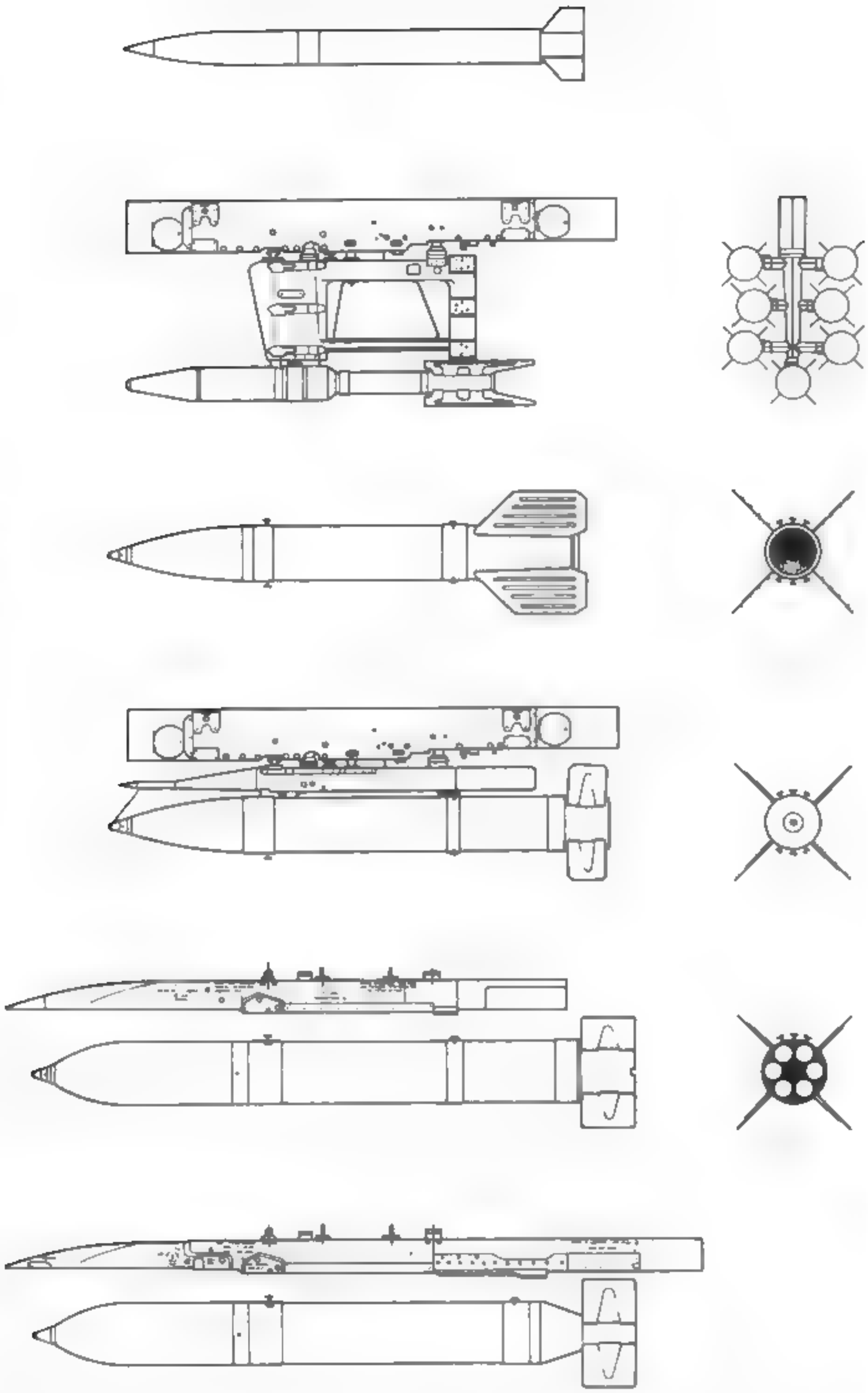
By the end of 1937 the RNII design staff, then headed by A. G. Kostikov and Yuriy A. Pobedonostsev, had completed tests of the 82-mm (3.22-in) RS-82 and 132-mm (5.19-in) RS-132 long-finned unguided rockets and their associated RO-82 and RO-132 launch rails. (RS = *reaktivnyy snaryad* - rocket projectile, RO = *reaktivnoye oroodiye* – lit. 'rocket gun', that is, launcher.) Before the outbreak of the Great Patriotic War on 22nd June 1941 they had become part of the armament of the Polikarpov I-15, I-15*bis*, I-153 Chaika (Seagull) and I-16 fighters, as well as the Tupolev SB 2M-100A (ANT-40) and SB 2M-103 (ANT-40*bis*) fast bombers. In the wartime years the rockets were carried by the Yakovlev Yak-1, Yak-7 and Lavochkin/Gorboonov/Goodkov LaGG-3 fighters, Il'yushin IL-2 attack aircraft and other types.

Actually the first operational use of aircraft rockets in the Soviet Union (or anywhere else, for that matter) occurred *before* the Second World War, namely when the USSR clashed with Japan in armed conflict near the Khalkhin-Gol River in 1939. During the air war over the Khalkhin-Gol Red Army Air Force fighters used RS-82s against Japanese aircraft, firing the rockets at enemy aircraft formations at a range of 800 m (2,620 ft) or more. All in all, the group of six rocket armed I-16s involved in the conflict



Top. Armourers prepare two RS-82 rockets for hooking up to an aircraft. The propeller-like fuse arming vanes are clearly visible.

Above: The main components of the RS-82 – the rocket motor body, the nozzle portion, the tail fairing with stabilising fins, the warhead and the fuse (less vane).



Left, top to bottom. The 132-mm S-13 rocket; the APU-14U rocket launcher with S-3K rockets hooked up to a BD3-57 pylon (only one rocket is shown for clarity in the side view); the 212-mm S-21 (ARS-212) rocket; an S-21M rocket on a PU-21 (APU-O-212) launch rail hooked up to a BD3-57 pylon; the 240-mm S-24 (ARS-240) rocket with an APU-7 launch rail; and the S-24BNK rocket with an APU-68UM2 launch rail.

shot down seventeen Japanese aircraft, expending 413 rockets in so doing.

At the beginning of the Second World War unguided aircraft rockets were still used only by the Red Army Air Force. The available range of models comprised the high-explosive RS-82 and RS-132, the HE/fragmentation ROFS-132 (*reaktivnyy oskolochno-foogahsnyy snaryad*), the shaped-charge anti-tank RBS-82 and RBS-132 (*reaktivnyy broneboynyy snaryad* - armour-piercing rocket projectile), they were used on both fighters, attack aircraft and bombers. By comparison, the Luftwaffe and the Royal Air Force did not begin using rocket projectiles until 1943, the US Army Air Force following suit a year later

As far as their 'killing power' is concerned, the unguided rockets fit in between bombs and cannons. Unlike free-fall bombs, they can be placed on the target with great accuracy, their demolition and splinter generation effect exceeds that of cannon shells. For instance, the 37-mm (1.45 calibre) round of the Nudelman N-37 aircraft cannon weighs 758 grams (26.75 oz), whereas the high-explosive charge of the smallest contemporary unguided rocket – the 57-mm (2.24-in) S-5 folding-fin aircraft rocket – weighs 815 grams (28 76 oz). A cannon shell's muzzle velocity – 690 m/sec (2,263 ft/sec) in the case of the N-37 – is much higher than the speed of an unguided rocket as it leaves the launcher; in this case, 70 m/sec (230 ft/sec) for the S-5. This endows the cannon shell with higher accuracy; on the other hand, the long active stage of an unguided rocket's flight path (that is, when the rocket motor operates) gives it a much longer 'kill' range – up to 2,000 m (6,560 ft) versus 600 m (1,970 ft) for cannon shells

The success achieved with unguided rockets in the Second World War paved the way for further development of this class of weapons in the post-war years. Compared to other aircraft weapons of the day, the unguided rockets boasted the advantages of a longer 'kill' range, a bigger explosive charge, design simplicity and ease of use The ability of attack aircraft to carry a large number of rockets and unleash them in a salvo or ripple increased the chances of destroying the target

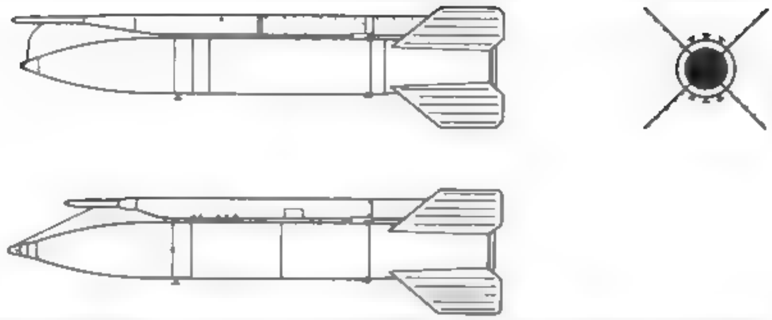
The chief shortcoming of unguided rockets is their relatively poor accuracy, especially at maximum range. To overcome this problem the early rockets were provided with large stabilising fins. Another approach to the problem is to use spin-stabilised rockets featuring angled rocket motor nozzles to impart a rotation around the weapon's axis at about 1,200 rpm In Russian such rockets are called, rather confusingly, *toorboreaktivnyy snaryad* – 'turbojet projectile', although they are propelled by solid-fuel rocket motors, not turbojet engines The first such weapons in the Soviet Union were the pre-war TRS-82 and TRS-132

After the Great Patriotic War development of unguided rockets and launchers for same in the Soviet Union became the domain of OKB-16 led by Aleksandr Yakovlevich Nudelman, a designer better known for his aircraft cannons (the N-37, NS-37, NR-37, NR-30 and others).

S-21 (ARS-212) unguided rocket

The S-21, alias ARS-212 (*aviatsionnyy reaktivnyy snaryad* – aircraft rocket projectile)

was one of the first high-velocity aircraft rockets (HVARs) to be developed in the Soviet Union in the immediate post-war years Two of these 212-mm (8 34-in) high-explosive/fragmentation rockets, together with their launch rails, formed the AS 21 weapons system designed for use against aerial and ground targets alike. The launch rails were designated PU-21 (*pooskovoye oostroystvo* – launcher) or APU-O-212 (*aviatsionnoye pooskovoye oostroystvo, odinochnoye, [dlya snaryadov kalibra] 212 millimetrov* – aircraft-mounted launcher, sin-



Above right: An S-21 (ARS-212) rocket on a PU-21 launch rail wit the fuse arming cable in place, and the S-21 with a V-21 fuse on an APU-2 launch rail.

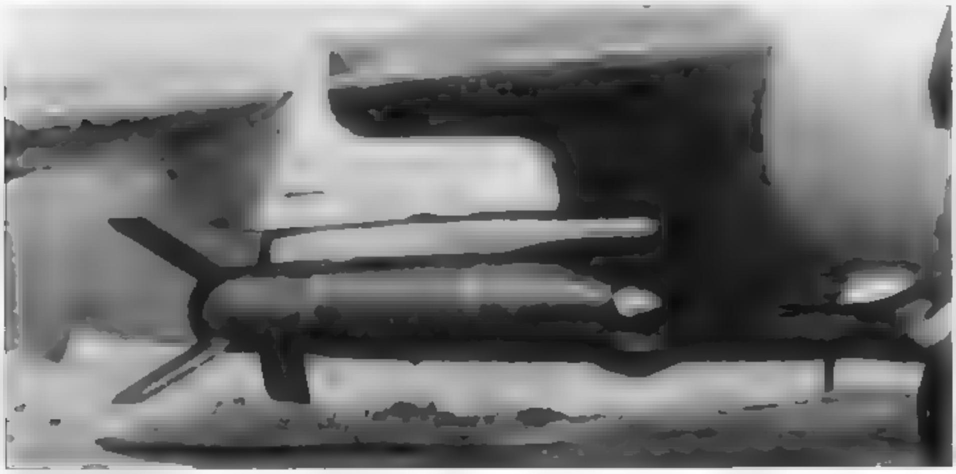
Right. This view shows how the SD-21 could carry the rockets together with 600-litre (132 Imp gal) 'slipper tanks' The drop tanks had to be jettisoned for safety reasons before the rockets could be fired.

Below: The Kuibyshev-built MiG-15*bis* (SD-21) weapons testbed ('407 Red , c/n 134007) with two S-21s on pylon-mounted PU-21 launch rails

The following tables give the specifications of OKB-16's rockets.

	RS-82	TRS-82	RS-132	TRS-132
Service entry	1937		1937	
Calibre	82 mm (3.22 in)	82 mm (3.22 in)	132 mm (5.19 in)	132 mm (5.19 in)
Length overall	n.a.	n.a.	n.a.	n.a.
Fin span	n.a.	n.a.	n.a.	n.a.
Launch weight, kg (lb)	6.82 (15.0)	4.82 (10.62)	23.1 (50 92)	25.3 (55.77)
Warhead weight, kg (lb)	n.a.	n.a.	n.a.	n.a.
'Kill' range, km (miles)	n.a.	n.a.	n.a.	n.a.
Launch rail type	RO-82	[RO-82]	RO-132	[RO-132]
Launch platform	I-16 LaGG-3 Yak-1 IL-2 IL-10		IL-2 IL-10	


03

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Opposite page:

Top left: '03 Red', the Gor'kiy-built MiG-17 (SI-21) weapons testbed (presumably ex-'443 Red', c/n 54210443) showing the straight missile pylons carrying S-21 rockets on PU-21 launch rails.

Upper left: Close-up of the starboard L-shaped weapons pylon of the MiG-17 (SI-21M). The rocket is a version of the S-21, note the high aspect ratio swept fins.

Lower left: Overall view of '421 Red' (c/n 54210421), the MiG-17 (SI-21M) weapons testbed. Note the cine camera 'egg' on the drop tank hardpoint to capture the rocket launch.

Bottom left: '406 Red' (c/n 59210406), the SM-2A weapons testbed based on the MiG-19 *sans suffixe* (*Farmer-A*). Once again, the S-21 rockets are carried on straight pylons, but this time on APU-2 launch rails

Top right: The S-21 (ARS-212) in its initial form, showing the large trapezoidal fins.

Bottom right. The modified S-21M (ARS-212M). The small rectangular fins (augmented by canted nozzles to impart a rotation) and the proximity fuse with an annular transmitter receiver aerial are clearly visible.

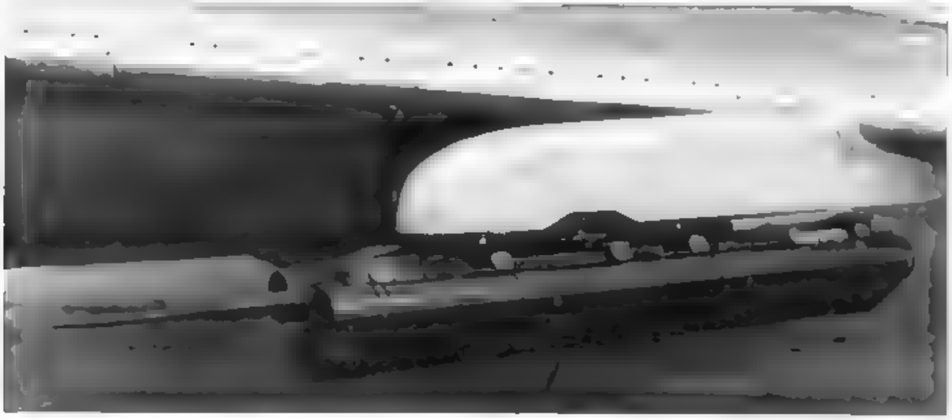
This page.

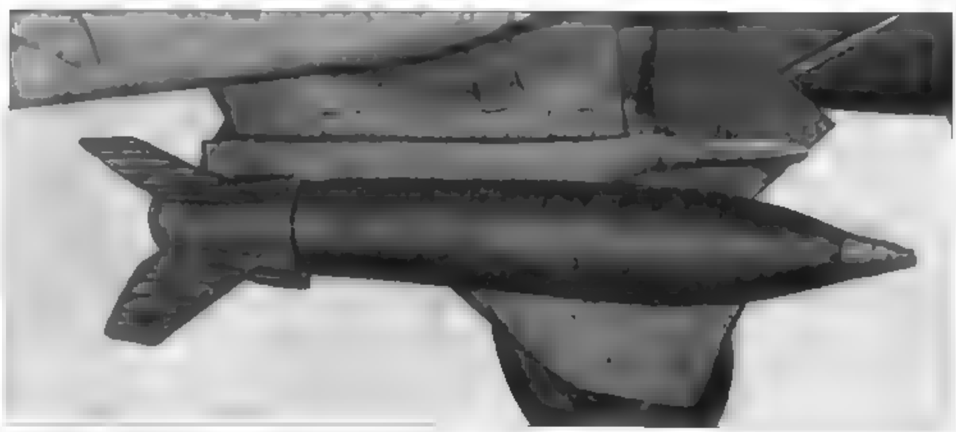
Top right: Close-up of the ORO-190 launch tube housing a TRS-190 rocket on the port pylon of '104 Red' (c/n 1401004), the Kuibyshev-built MiG-17 (SI-19) weapons testbed.

Upper right: Two TRS-190K spin-stabilised rockets on the inner and outer hardpoints of a MiG-19 in the SM-2 weapons testbed series. As distinct from the tube-launched TRS-190 *sans suffixe*, the TRS-190K was launched from a rail.

Lower right: Another weapons installation tested on the SM-2 series was this neat three-pack of launch tubes housing 85-mm RS-85 folding-fin aircraft rockets. Note the spike in the middle.

Bottom: This horribly retouched photo from an old Soviet 'NKO' (for those who Need to Know Only) booklet shows yet another weapon tested on the MiG-19/SM-2 – the very large 280-mm (11-in) RS-280 unguided rocket.





Left: Two APU-14M seven-round rocket launchers on the fuselage hardpoints of a Su-7B fighter-bomber, seen from behind. Note that the centre pairs of struts on each side are shorter than the upper and lower pairs to prevent the fins of the centre and upper/lower S-3K rockets from striking each other.

gle, for 212-mm HVARs). The rockets could be fired singly or in a salvo.

The AS-21 was intended for the MiG-15*bis*, MiG-17AS, MiG-19 and other jet fighters. The MiG-15*bis* (*izdeliye* SD-21) development aircraft ('407 Red', c/n 134007) and the MiG-19 (*izdeliye* SM-21) development aircraft/weapons testbed ('406 Red', c/n 59210406?) brought out in 1952 and 1957 respectively both featured additional hardpoints for the rockets between the main landing gear units and the standard 'wet' wing hardpoints. On the 'production' MiG-17AS fighter-bomber – an *en masse* conversion of MiG-17s *sans suffixe* (*Fresco-As*) retired from first-line fighter duties – two special pylons protruding beyond the wing leading edge were provided for the S-21s

The rocket is detonated by a condenser-type impact/proximity fuse with a variable delay time; the latter depends on the voltage applied to the fuse before launch and can be set automatically by a rheostat on the special AP-21 sight based on the standard ASP-3NM. Accurate sighting range is 400-800 m (1,310-2,620 ft) for the rockets and 180-800 m (590-2,620 ft) for the standard cannons; however, the sight does not enable simultaneous cannon fire and rocket launch, which means one of two sighting modes (cannons or rockets) has to be selected before commencing an attack. An S-21 exploding up to 15 m (50 ft) behind a bomber is sure to blast it out of the sky

The design of the S-21 is based on that of the RS-82 and RS 132. The rocket consists of a HE/fragmentation warhead, a solid-fuel rocket motor and four stabilising fins welded to the body. The rocket's maximum speed at sea level is 385 m/sec (1,386 km/h, or 860 mph)

S-21M (ARS-212M) unguided rocket

A more refined version designated S-21M (ARS-212M) was developed and adopted for Soviet Air Force service. It featured increased accuracy attained thanks to new rectangular stabilisers with a revised airfoil and an altered rocket motor nozzle; the single nozzle of the S-21 is replaced by six small nozzles set at an angle to the rocket's axis in order to impart a stabilising spin S-21M rockets were carried on PU-12-40 launch rails suspended on BD3-57 pylons

S-1 OF (TRS-212) unguided rocket

The 212-mm S-1 OF (TRS-212) unguided rocket is representative of the finless spin-stabilised rockets. As compared to finned rockets, such weapons are more stable in flight, especially at high altitudes (where the rarefied air renders fins inefficient) and when launched backwards to foil a stern attack

The S-1 OF is strictly an air-to-ground weapon In size and performance it is similar to the dual-purpose, finned S-21 and has a similar HE/fragmentation warhead (hence the OF suffix for *oskolochno-foogahsnyy* [*snaryad*]) and solid-fuel rocket motor. The principal difference is that the single nozzle is replaced by a cover with 12 small angled nozzles creating both forward thrust and rotation. Also, the S-1 OF has an impact fuse

A further difference lies in the launch technique. S-1 OF rockets require special launch tubes

S-19 (TRS-190) unguided rocket

The 190-mm (7.48-in) S-19, alias TRS-190, is another early post-war large-calibre HVAR Again, it is a finless spin-stabilised rocket with angled nozzles.

The S-19 was put through its paces on the MiG-17 (*izdeliye* SI-19) experimental fighter-bomber/weapons testbed serialled '104 Red' (c/n 1401004) Two pylons were fitted in line with the inboard boundary layer fences for carrying single ORO-190 launch tubes (*odnozaryadnoye reaktivnoye oroodiye* – lit. 'single-round jet gun'; see S-5 below for an explanation of this term) Alternatively, the rockets could be carried on special pylons installed at the regular drop tank hardpoints; in this case the inboard pylons were removed

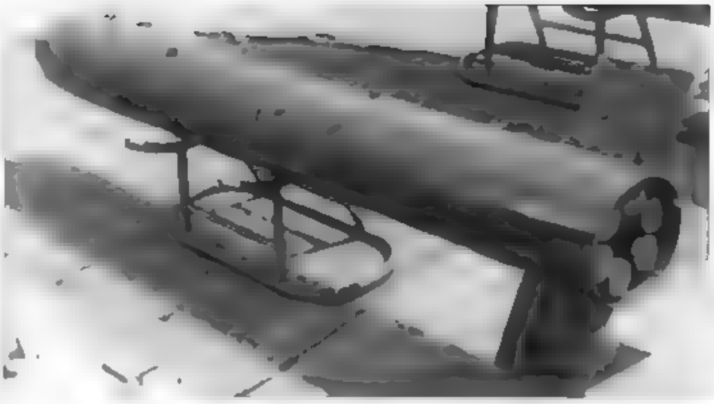
The results were apparently disappointing, as the S-19 rocket was not cleared for Soviet Air Force service

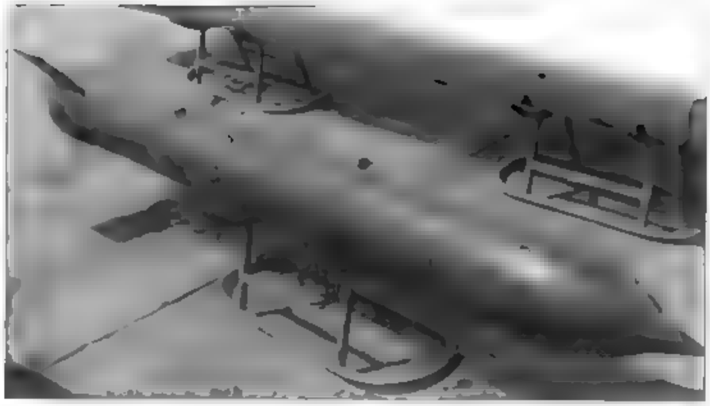
S-3K (KARS-160) unguided rocket

The 160-mm (6.3-in) S-3K, alias KARS-160 (*kumulyativnyy aviatsionnyy reaktivnyy snaryad* – shaped-charge aircraft rocket projectile), has the same basic design as the S-21 but differs in aerodynamic form, having a warhead of larger calibre than the body This design feature made it possible to increase the weight of the charge and its destructive power

The cruciform stabilising fins attached to the nozzle shroud are modified, extending

An S-24 heavy unguided rocket on a transporter/loader dolly with a scissor lift and a hand-driven hydraulic pump. No fuse is fitted yet.





Above, left and right. Two views of the S-24B concrete-piercing rocket. Note the six angled rocket motor nozzles closed by protective covers.

aft of the nozzle. The greater fin area makes for acceptably high accuracy.

The combined shaped-charge/high-explosive/fragmentation warhead makes the rocket suitable for use against armoured vehicles and reinforced structures as well as personnel. The hollow charge is capable of burning through armour plate up to 300 mm (11 13/16 in) thick, while the hatched metal outer shell generates up to 500 fragments as it bursts open.

The S-3K was carried on the special APU-14U launchers that were fitted exclusively to the Sukhoi Su-7B fighter-bomber. This seven-round launcher had a curious tree-like shape when seen from the front, with three rockets each side on horizontal rails and a seventh suspended underneath. The APU-14U was the first multiple launcher designed for heavy unguided rockets, and its peculiar design was caused by the need to accommodate several rockets with cruciform fins of considerable span. However, the launcher created strong drag and therefore did not find use on any other aircraft type.

S-24 (ARS-240) unguided rocket

The combat efficiency of the first production heavy HVARs – the S-21 and S-21M – left a lot to be desired because of the short range, poor accuracy and small warhead. To remedy this, OKB-16 brought out the 240-mm (9.44-in) S-24 HVAR which was introduced into the Soviet Air Force inventory in the mid-1960s.

Basically the S-24 is a scaled-up version of the S-21M. Its more powerful solid-fuel rocket motor features six nozzles arranged around the perimeter of the backplate and angled to impart a rotation at 450 rpm. When the rocket motor burns out 1.1 second after launch, stabilisation is provided by the angled and specially profiled fins. The S-24 has a 123-kg (271-lb) warhead containing 23.5 kg (51.8 lb) of explosives. The metal body of the warhead is thermally treated and features special tension concentrator grooves on the inside to guarantee that the body splinters into 4,000 fragments with a lethal radius of up to 400 m (1,310 ft).

Experience shows that up to 70% of the splinters remain inside the crater in a ground explosion of an air-to-ground weapon. Therefore, to increase the rocket's 'killing power' the S-24N version featuring an RV-24 radar proximity fuse was developed (N = *nekontaktnyy vzryvahtel'* – proximity fuse); the fuse detonated the warhead 30 m (100 ft) above the target.

The S-24B (*betonoboynyy* – concrete-piercing) was developed for use against tough structures, including those with rein-

Above right: An S-24B rocket on the starboard wing pylon of a Batch 12 Su-7BM fighter-bomber (c/n 123...). The S-24s were carried on very small and neat launch rails. The conical impact fuse is clearly visible.

Right: A pair of S-24Bs on the fuselage pylons of Su-7BM c/n 1101. Up to four of these weapons could be carried.

Above: Front view of a Su-7BM with a full complement of S-24 unguided rockets. Despite the nose air intake, the Su-7's engine operation was apparently unaffected by the exhaust plumes of the departing missiles.

	S-21 (ARS-212)	**S-5 (ARS-57)**	**S-3K (KARS-160)**	**S-24 (ARS-240)**
Service entry	n.a.	n.a.	n.a.	n.a
Calibre	212 mm (8 34 in)	57 mm (2.24 in)	160 mm (6.3 in)	240 mm (9 44 in)
Length overall	1.766 m (5 ft 9 17/32 in)	0.915 m (3 ft 0 in)	1.5 m (4 ft 11 in)	2.22 m (7 ft 3 13/32 in)
Fin span	0.64 m (2 ft 1 3/16 in)	0.232 m (9⅛ in)	0.24 m (9 7/16 in)	0.60 m (1 ft 11⅝ in)
Launch weight, kg (lb)	117 (258)	3.99 (8.79)	23.5 (51.8)	235 (518)
Warhead weight kg (lb)	40 (88)	1.16 (2.55)	7.3 (16)	123 (271)
'Kill' range, km (miles)	0.8 (0.5)	2 (1.24)	2 (1.24)	n.a
Launch rail (pod) type	PU-21 PU-12-40	RO-57-8 (ORO-57) UB-16-57 UB-32-57 and others	APU-14U	PU-12-40U APU-7D APU-68 and others
Launch platform	MiG-15bis (SD-21) MiG-17AS MiG-19S Su-7B MiG-21F-13	MiG-15bis (SD-57) MiG-19 Su-7B *et seq* MiG-21F thru MiG-29 Mi-4AV Mi-8T Mi-24 Ka-29TB	Su-7BKL	Su-24 MiG-21PF thru MiG-21bis MiG-23 MiG-27

forced concrete roofs It features an impact fuse with three selectable time delay values, the appropriate value is selected prior to the mission to suit the target type The delay ensures that the warhead detonates after its heavy-duty metal shell penetrates the roof or wall of the target structure. The S-24B also has a modified rocket motor

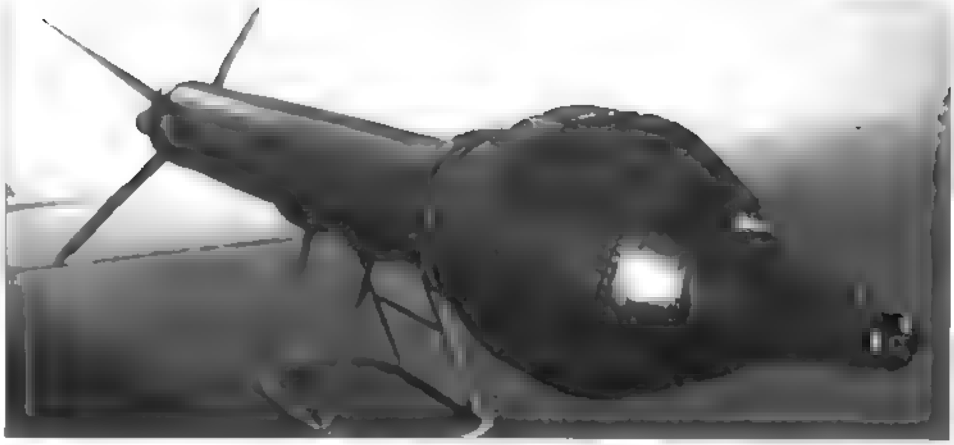
The S-24BNK (*broneboyno-kumulyativnyy* – armour-piercing/shaped-charge) is intended for destroying armoured vehicles Again, it has an impact fuse with selectable time delay values for maximum efficiency

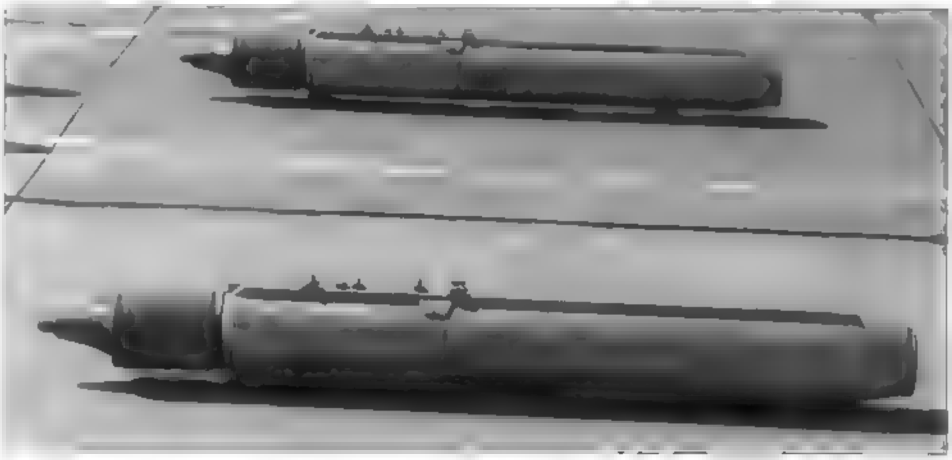
The first type to carry the S-24 was the Su-7B fighter-bomber, later augmented by other aircraft in the same category. Initially the rockets were carried on PU-12-40U launch rails, these were superseded by the more advanced APU-7D model from 1982 onwards Later still, as the Air Force strove for components commonality between weapons systems, the S-24 was launched from the APU-68U and other multi-purpose launch rails allowing the carriage of guided missiles as well as unguided rockets

The S-24's reliability and simplicity turned it into one of the most widespread air-to-ground weapons in the Soviet Air Force's tactical arm and the Soviet Army Aviation For instance, the Su-7B and Su-17 fighter-bombers and the Su-25 attack aircraft can carry up to four, six and eight S-24s respectively. Part of the Soviet Army's Mil' Mi-24V assault helicopter fleet was also modified for carrying S-24 HVARs. The MiG-21PF tactical fighter could carry two of these rockets

S-25 unguided rocket

The final heavy unguided rocket to be developed in the USSR was the 250-mm (9 84-in) S-25 ultra-heavy folding-fin aircraft rocket (FFAR). This weapon utilises a number of unconventional design features. Unlike other unguided rockets, it comes from the factory pre-loaded into a PU-O-25 launch tube (*pooskovoye oostroystvo, odnorazovoye, [dlya snaryada S-] dvadtsat' pyat'* – launcher, disposable, for S-25 rocket); the tube is wooden, with a metal outer skin. This

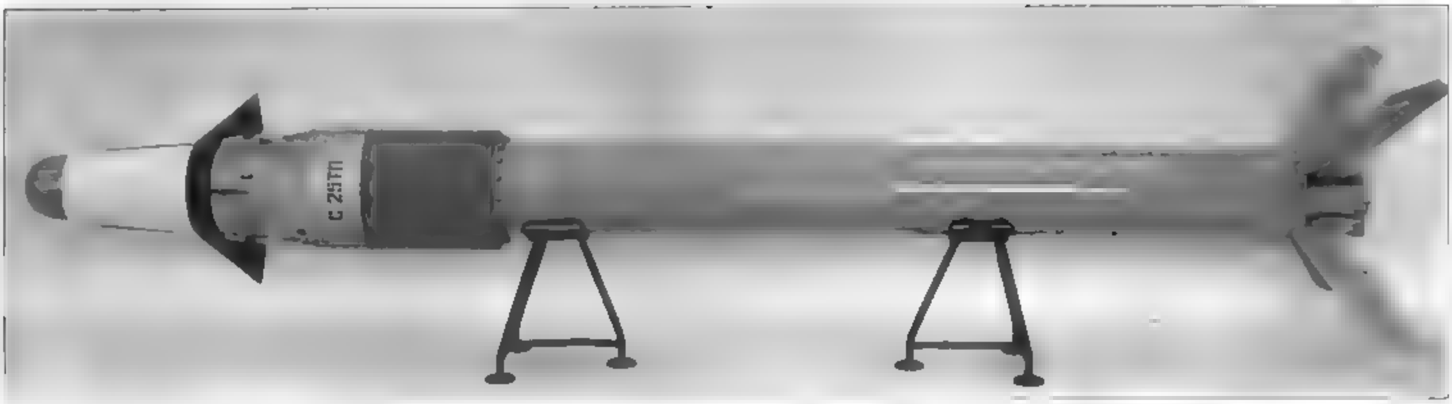




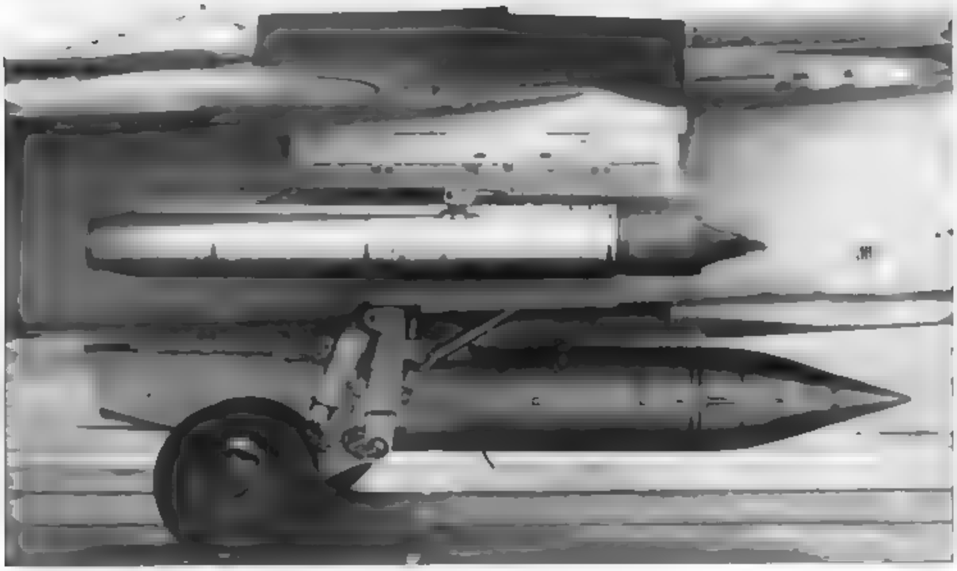
Top right: An S-25-OF missile out of its disposable launch tube and with the fins deployed. The bulbous 'pineapple' high-explosive/fragmentation warhead is clearly visible; note the thimble-like fuse fairing and the external hatching on the metal shell of the warhead to facilitate splinter formation.

Centre left and above left: S-25-OFM rockets in PU-O-25 launch tubes. This version is identifiable by the cylindrical warhead with a conical nose.

Right: The S-25L is actually not a rocket but a laser-guided missile. The laser seeker head and the delta-shaped rudders are clearly evident.



Above. The S-25TP is also a guided air-to-surface missile differing from the S-25L in having an infra-red seeker head. The deployed fins and the rocket motor nozzles are visible here.



Left. An S-25-OFM on the starboard wing glove pylon of Su-24MK '93 Blue' at Kubinka AB

feature facilitates the rocket's operational use, especially transportation and storage

The S-25 has four stabilising fins similar to those of the much smaller S-8; when the rocket is loaded into the launch tube the fins fold forward to lie between the four nozzles of the rocket motor. The nozzles are set at an angle to the rocket's axis in order to create a stabilising spin; a tracer is installed between them to assist visual tracking and gun camera recording of rocket launches

Several versions of the S-25 optimised for different kinds of targets and equipped with different warheads were brought into the inventory. Regardless of version, the warhead's calibre is larger than that of the body to maximise the destructive power, hence the cylindrical warhead is exposed, being located outside the launch tube.

The S-25-O (*oskolochnyy*) has a powerful 150-kg (330-lb) fragmentation warhead of 370 mm (14½ in) diameter. The casing of the warhead is cross-hatched to generate no fewer than 10,000 fragments when the charge explodes. The rocket has an RV-25 radar proximity fuse detonating the warhead 5-20 m (16-65 ft) above the target. Trials showed that a single well-aimed S-25-O can kill or disable as much as an entire infantry battalion

The S-25-OF (*oskolochno-foogahsnyy*) is intended for use against personnel, structures and lightly armoured vehicles It has an HE/fragmentation warhead of 340 mm (13 25/64 in) diameter weighing 194 kg (427 lb) and is fitted with an impact fuse for maximum demolition effect

The S-25-OFM (*oskolochno-foogahsnyy, modernizeerovannyy*) has an upgraded HE/fragmentation warhead with a reinforced casing for broaching thick-walled or reinforced concrete structures before the warhead explodes within. The warhead features a built-in time-delay fuse enclosed by a fairing, the external diameter is reduced to 300 mm (11 13/16 in).

As noted in the previous chapter, the S-25L is the odd man out in the picture, being in fact an air-to-surface missile and

	S-25-O	S-25-OF	S-25-OFM	S-25L
Service entry	n.a	n.a.	n.a	n a
Calibre	250 mm (9 84 in)	250 mm (9 84 in)	250 mm (9.84 in)	250 mm (9 84 in)
Length overall	3.775 m (12 ft 4 5/8 in)	3.54 m (11 ft 7.37 in)	3.54 m (11 ft 7.37 in)	3 85 m (12 ft 7.57 in)
Fin span	1 05 m (3 ft 5⅓ in)	1.05 m (3 ft 5⅓ in)	1 05 m (3 ft 5⅓ in)	1 05 m (3 ft 5⅓ in)
Launch weight, kg (lb)	370 (815)	410 (903)	370 (815)	410 (903)
Warhead weight kg (lb)	150 (330)	1941 (427)	150 (330)	1941 (427)
'Kill' range. km (miles)	4 (2.48)	4 (2.48)	4 (2.48)	3-8 (1 86-5)
Launch pod type	PU-O-25	PU-O-25L		
Launch platform		Su-17M2 *et seq*, Su-25, Su-25TK, Su-34		

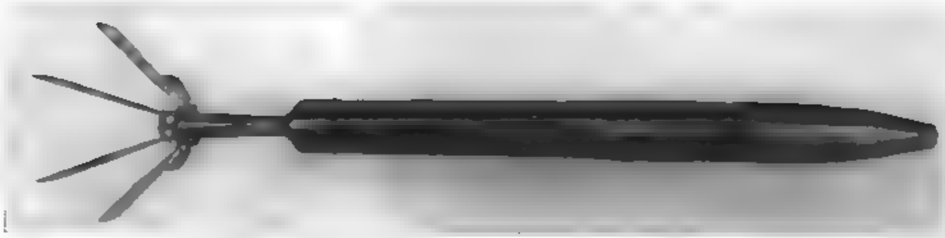
Right: The S-5 (ARS-57) Skvorets folding-fin aircraft rocket with the eight fins deployed. Note the way they are shaped to fit around the long jetpipe and swept back in deployed position.

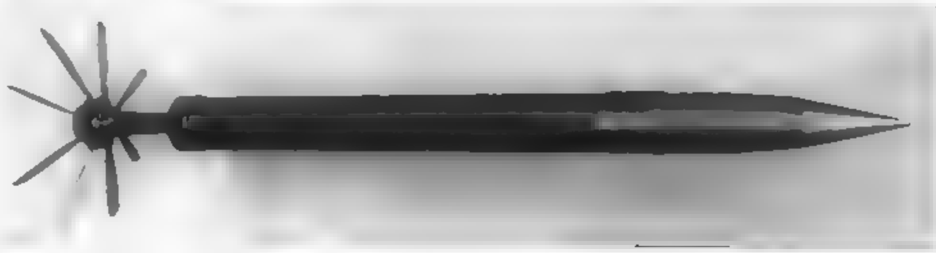
Below right. The S-5M (ARS-57M) FFAR features a longer body, a more pointed nose and shorter fins which are almost unswept when deployed.

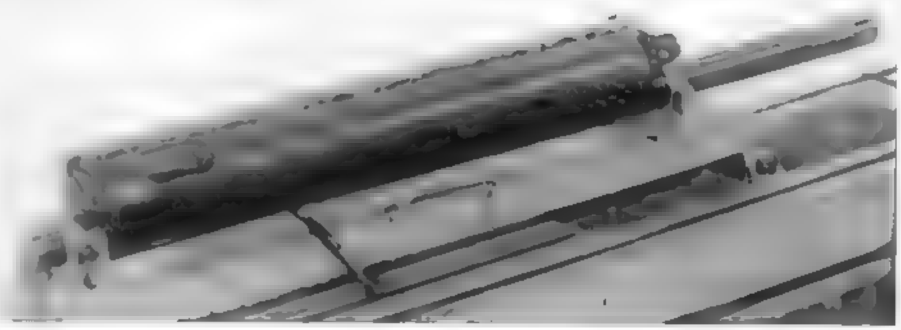
Centre right: The ARO-57-4 four-round rocket launcher. Four such units were to be buried in the wing roots of the Mikoyan I-7U and I-7P.

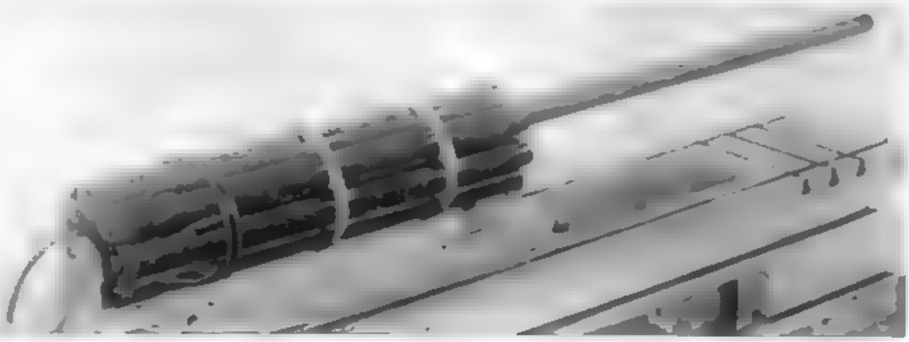
Bottom right: The ARO-57-8 (3P-8-II) eight-round revolver-type launcher.

Foot of page: The RO-57-8 (ORO-57K) FFAR pods on the MiG-19 (SM-57, empty) and a standard MiG-19 (loaded).









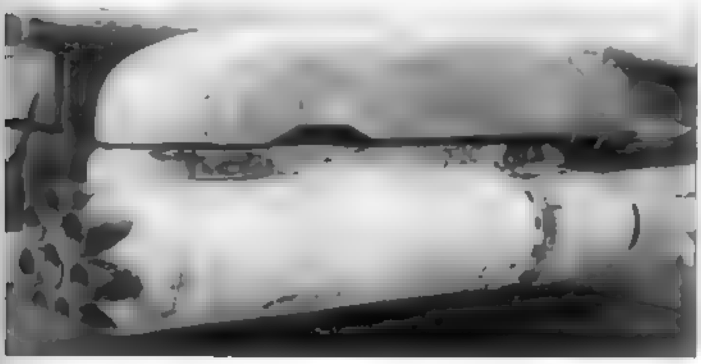
illustrating how unguided weapons can evolve into guided ones. Actually it is a precision-guided munition, being an S-25-OFM modified by fitting a special body section ahead of the warhead; this houses an *izdeliye* 24N1 laser seeker head, a self-contained actuator pack and rudders for controlling the missile's flight. The laser seeker head is of the passive variety, requiring the target to be illuminated by a laser designator The cruciform canard rudders have delta planform. The S-25L comes complete with the PU-O-25L disposable launch tube which has maximum possible commonality with the regular PU-O-25 The S-25TP is identical, except for the IR seeker head

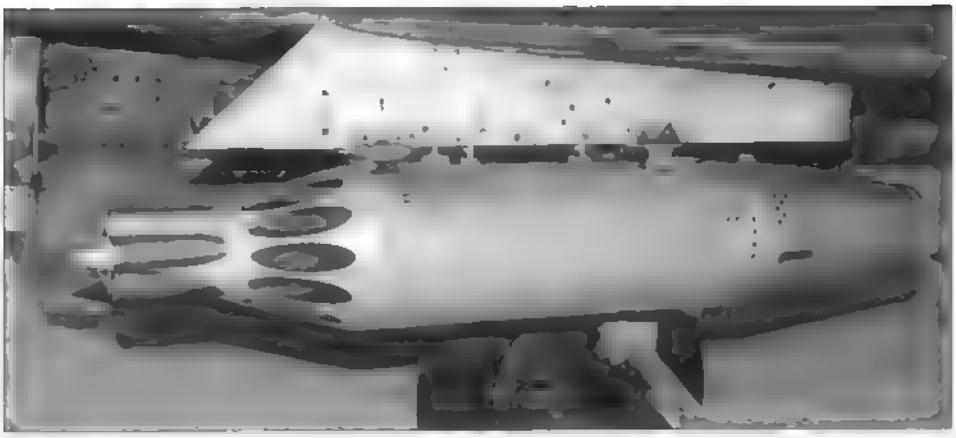
S-5 (ARS-57) Skvorets folding-fin aircraft rocket

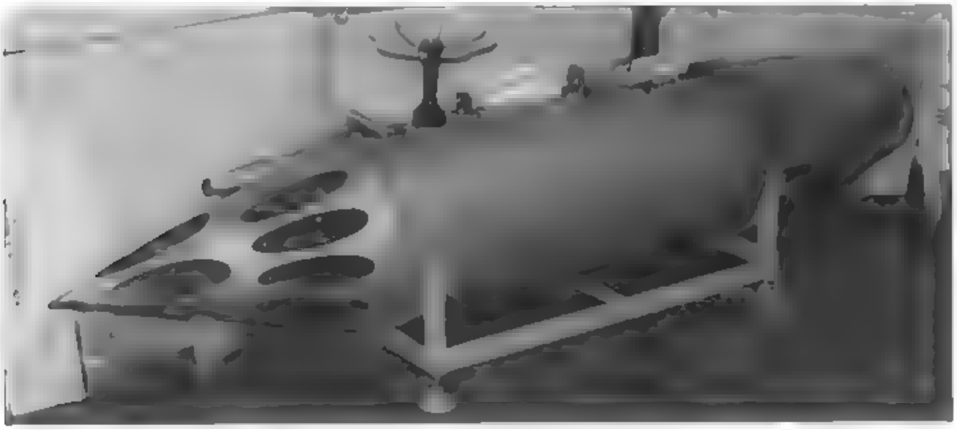
Known initially as the ARS-57 and bearing the popular named *Skvorets* (Starling), the S-5 folding-fin aircraft rocket has the same 57-mm (2.24-in) calibre as used by some artillery systems. Created in the early 1950s, the S-5 was originally developed as an air-to-air weapon designed for attacks at altitudes up to 20,000 m (65,620 ft) and ranges up to 2 km (1.24 miles), with a possible air-to-ground role. Eventually, however, this secondary role became the S-5's principal one. The S-5 was developed as part of the AS-5 aircraft weapons system intended for the MiG-19 tactical fighter. Besides the FFARs, the system included eight-round RO-57-8 rocket pods and the ASP-5N optical sight.

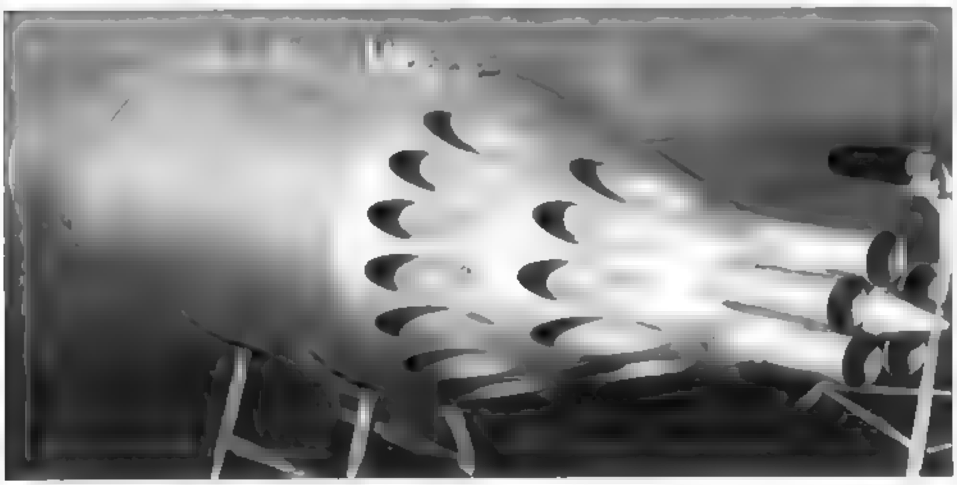
The S-5 rockets underwent trials on the MiG-15*bis* (*izdeliye* SD-57) development aircraft serialled '803 Red' (c/n unknown); the fighter carried two experimental RO-57-12 rocket pods, each with twelve ORO-57 launch tubes. As for the RO-57-8 pods, they were put through their paces on the MiG-17 (*izdeliye* SI-16) experimental fighter-bomber/weapons testbed ('005 Red', c/n 54211005) during January-June 1954. A further weapons testbed, the MiG-19 (*izdeliye* SM-57), served for testing three- and five-round FFAR pods developed for the S-5, four pods were carried in both cases

The Mikoyan OKB tried using the AS-5 weapons system with RO-57-8 rocket pods









Left: The 16-round UB-16-57 FFAR pod was manufactured in several variants. This example has long-barrelled launch tubes on the inner row of five which are a characteristic feature of the helborne UB-16-57UMVP; nevertheless, it is suspended beneath a MiG-21 fighter. The open-end tail fairing is detachable for loading.

Below right: A different version of the UB-16-57 with a smooth conical nose (that is, without protruding launch tubes. This one is a training mock-up duly marked *Oochebnyy maket*. Note the jetpipe/stabiliser assembly of an S-5M rocket perched on top.

Bottom right: The 32-round UB-32-57 FFAR pod is basically a scaled-up version of the UB-16-57

on the MiG-17PF (*izdeliye* SP-9) weapons testbed ('627 Red', c/n 58210627) completed in January 1955. The aircraft was armed with a quartet of six-round ARO-57-6 Vikhr' (Whirlwind) automatic rocket launchers, aka 3P-6-III, looking like outsize revolvers with a long barrel. (ARO-57-6 = ***avtomaticheskoye reaktivnoye oroodiye kalibra pyat'dyesyat sem' millimetrov na shest' zaryadov*** - lit. 'six-round 57-mm automatic jet gun'.) Additionally, it could carry up to four RO-57-8 pods on the regular drop tank hardpoints and two streamlined pylons inboard of these; this gave a maximum ammunition supply of 56 S-5 rockets. However, tests revealed that FFARs were of little use against aerial targets. An eight-round revolver-type launcher designated 3P-8-II (ARO-57-8) also existed.

The S-5 consists of a solid fuel rocket motor with a steel body, to which a high-explosive warhead with an impact fuse and an elongated nozzle are attached. The nozzle rim carries eight forward-folding stabilising fins, these are shaped to fit around the jetpipe when folded, not protruding beyond the body diameter. The required fin area is provided by fitting an adequate number of fins. For storage and loading into the launcher the spring-loaded fins are retained by a cardboard or plastic ring which slips off as the rocket is slid into the launch tube from behind, allowing the fins to unfold as the rocket leaves the tube. The fins are specially profiled to spin the rocket around its axis at 750 rpm for added stability.

The fins are swept back when deployed, increasing the rocket's length. The S-5 is 0.825 m (2 ft 8 in) long in pre-launch condition and 0.915 m (3 ft 0 in) long with the fins deployed.

The rocket motor's burn time is just 1.1 second, in which time the S-5 covers a distance of about 300 m (980 ft). After burnout the rocket follows a ballistic trajectory like a cannon shell.

The simple and well thought-out design of the S-5 made it possible to create a whole range of versions differing in warhead type. The S-5M and S-5M1 are intended for use against aerial targets, soft-skinned ground targets and personnel. They have a high-explosive warhead with an outer skin disintegrating into some 75 splinters. The only difference is in the type of contactor used in the rocket motor ignition circuit; the S-5M uses a pin-type connector with wires, while the S-5M1 has a pair of metal half-rings on the rocket motor nozzle plug.

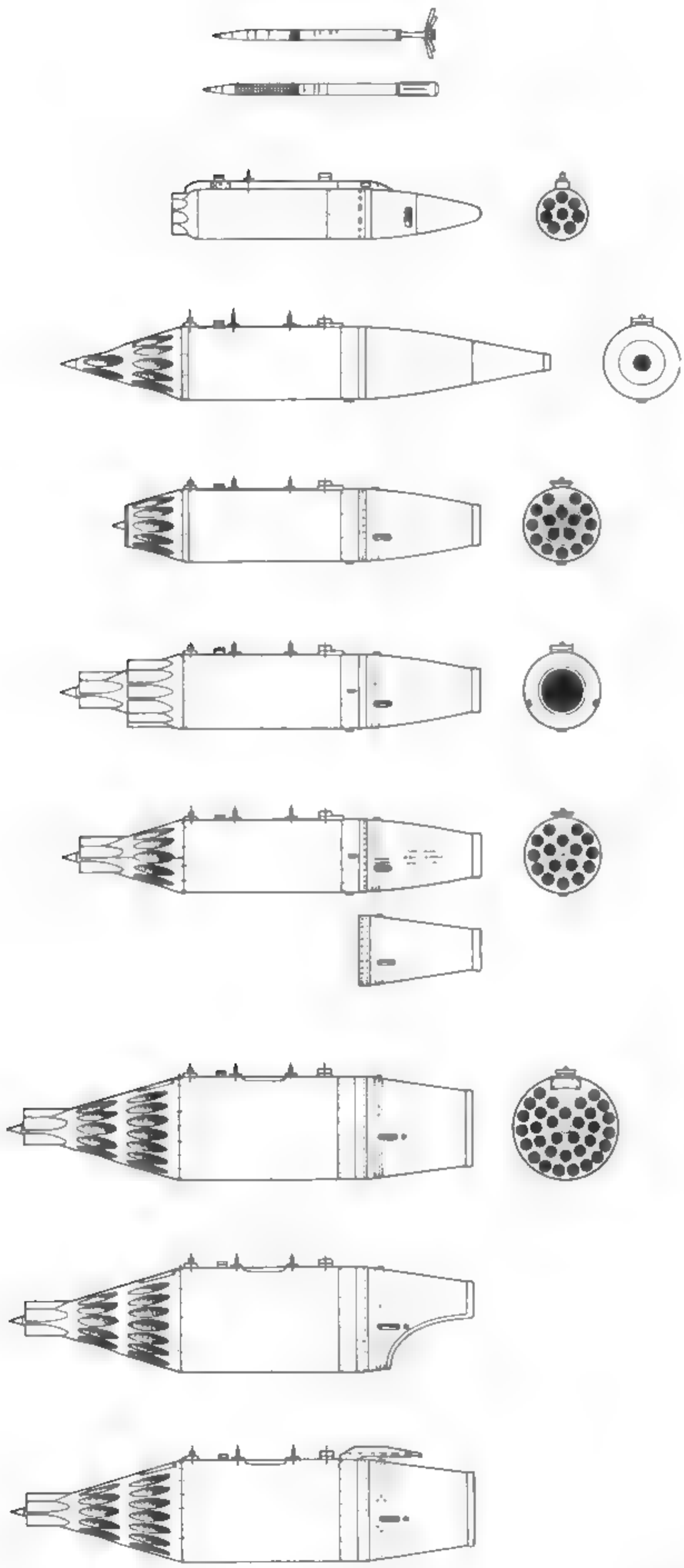
The S-5MO features a warhead with enhanced fragmentation effect featuring twenty notched steel rings around the explosive charge, they generate up to 360 fragments, hence the O for ***oskolochnyy***. The S-5K (***kumulyativnyy***; originally designated KARS-57) and S-5K1 are armour-piercing rockets with a shaped-charge warhead capable of burning through armour plate up to 130 mm (5¼ in) thick. The S-5KO (***kumulyativno-oskolochnyy***) has a combined fragmentation/AP warhead with ten notched steel rings around the shaped charge to create 220 fragments.

The S-5KP and S-5KPB differ from the previous two models in having a highly sensitive piezoelectric fuse instead of a mechanically actuated impact fuse (hence the P for ***p'yezoelektricheskiy vzryvahtel'***). The external fragmentation liner consists of wound steel wire.

All of the above versions have impact fuses and a self-destruct feature detonating the warhead when a certain time elapses if the rocket misses the target. A few special-

Above: A Soviet Air Force Su-7BMK poses with all of its various weapons options arrayed in front of it. The two 30-mm (1.19 calibre) cannons are foremost, followed by six UB-16-57 pods (totalling 96 S-5 FFARs), four APU-14U launchers (totalling 28 S-3K rockets), six S-24 rockets with PU-24 launch rails, plus 500-, -250- and 100-kg bombs and drop tanks.

w: A classic shot of the second prototype Su-25 (the T8-2D) armed with eight UB-32A FAR pods and two R-3T AAMs for self-defence



Top to bottom: The S-5 FFAR with the fins folded for loading and enclosed by a cardboard cover; the S-5M, the S-5KO; the RO-57-8 (ORO-57KM) rocket pod in empty condition; the UB-16-57U pod; the UB-16-57UD short-nosed pod (this version was produced under licence in Poland as the Mars-2); the UB-16-57UDM pod, the UB-16-57UMVP pod optimised for helicopters (with two alternative tail fairings); the UB-32A pod; the UB-32A-24 pod; and the UB-32M pod.

purpose versions of the S-5, however, are provided with proximity fuses detonating the warhead after the rocket covers a preset distance. These are described below.

The S-5S and S-5SB are specialised anti-personnel weapons featuring a warhead filled with 1,000-1,100 flechettes; these are stamped metal darts 40 mm ($1^{37}/_{64}$ in) long. The S suffix stands for *strela* - arrow or, in this case, flechette. The warhead is, in fact, a barrel from which the darts are ejected at great speed by a powder charge in the direction of flight, turning every living thing in their path into minced meat

The S-5P (*protivorahdiolokatsionnyy* [*snaryad*] – lit 'anti-radar round'; originally designated PARS-57) and S-5P1 are passive ECM rockets filled with metal-coated fibreglass strips. Exploding ahead of the aircraft (or behind it, depending on how the FFAR pods are oriented), these special rounds create clouds of chaff supposed to jam enemy air defence radars (or the fire control radars of pursuing fighters) and decoy radar-homing missiles. The chaff-filled rockets found use mainly on the Yak-28PP ECM aircraft which carried them in 16-round UB-16-57U pods under the outer wings

The S-5-O (*osvetitel'nyy* [*snaryad*] – lit. 'illumination round') and S-5-O1 are 'flare rockets', the powered equivalent of flare bombs, and are used to illuminate the targets during night strike or reconnaissance sorties In the case of the S-5-O1 the analogy with flare bombs is even more applicable because a parachute is deployed after the rocket motor burns out to extend illumination time

Initially the S-5 FFARs were fired from ORO-57K eight-round rocket pods. This designation calls for some explaining. The digits obviously refer to the calibre, while ORO stands for *odnozaryadnoye reaktivnoye oroodiye* – 'single-round jet gun' The 'jet gun' bit is an analogy with the recoilless guns tested on several pre-World War Two Soviet fighters, reflecting a design peculiarity of the ORO-57K's launch tubes whose breeches are sealed by plugs once the rockets have been loaded This feature increases the rockets' muzzle velocity but causes a deal of inconvenience during operational use due to the recoil force at the moment of launch and the considerable

	S-5	S-5M1	S-5MO	S-5K1
Service entry	n.a.	n.a.	n.a.	n.a
Calibre	57 mm (2.24 in)	57 mm (2.24 in)	57 mm (2.24 in)	57 mm (2 24 in)
Length overall	0.915 m (3 ft 0 in)	0.882 m (2 ft $10\frac{23}{32}$ in)	0.998 m (3 ft $3\frac{9}{32}$ in)	0.83 m (2 ft $8\frac{11}{16}$ in)
Fin span	0.232 m ($9\frac{1}{8}$ in)	0.232 m ($9\frac{1}{8}$ in)	0.232 m ($9\frac{1}{8}$ in)	0.232 m ($9\frac{1}{8}$ in)
Launch weight, kg (lb)	3.99 (8.79)	3.86 (8.5)	4.82 (10.62)	3.64 (8 0)
Warhead weight, kg (lb)	1 16 (2.55)	0.8 (1 76)	0.8 (1 76)	1.1 (2.42)
Kill range, km (miles)	2 (1.24)	2 (1.24)	2 (1.24)	2 (1.24)
Launch pod type	RO 57 8 (ORO-57K) UB-16-57U UB-16-57UD UB 16-57UDM UB-16-57UMVL JB-32A, UB-32A-24 UB-32M and others			
Launch platform	MiG 15*bis* (SD 57) MiG 17 (SI-16) MiG 17PF (SP 10) MiG-19 (SM-12/3) Su-7B *et seq* Su-17/Su-22 *et seq* Su-24 Su-25, MiG-21F *et seq*, MiG-23, MiG-27, Yak 28PP, Yak-36, Ya-38, IL-28Sh, IL-102 MiG-29, Mi-4AV Mi-8T, Mi-24, Ka-25F, Ka-29TB Ka-50			

	S-5KO	S-5KPB	S-5P1	S-5-O1
Service entry	n.a.	n.a.	n.a.	n.a.
Calibre	57 mm (2.24 in)	57 mm (2 24 in)	57 mm (2.24 in)	57 mm (2.24 in)
Length overall	0.987 m (3 ft $2\frac{27}{32}$ in)	1.079 m (3 ft $6\frac{15}{32}$ in)	1.073 m (3 ft $6\frac{1}{4}$ in)	0.948 m (3 ft $1\frac{5}{16}$ in)
Fin span	0 232 m ($9\frac{1}{8}$ in)	0.232 m ($9\frac{1}{8}$ in)	0.232 m ($9\frac{1}{8}$ in)	0.232 m ($9\frac{1}{8}$ in)
Launch weight kg (lb)	4 43 (9 76)	5.01 (11.04)	5.04 (11 11)	4.94 (10.89)
Warhead weight, kg (lb)	1.36 (3)	1 8 (3.97)	n.a.	1.73 (3.8)
'Kill' range, km (miles)	2 (1 24)	2 (1.24)	2 (1.24)	2 (1 24)
Launch pod type	RO 57 8 (ORO-57K) UB 16-57U UB 16-57UD UB 16 57UDM UB 16-57UMVL, UB-32A UB 32A 24 UB 32M and others			
Launch platform	MiG-15*bis* (SD 57) MiG 17 (SI 16) MiG 17PF (SP 10) MiG 19 (SM 12/3) Su 7B *et seq*, Su 17/Su 20 *et seq* Su 24 Su-25, MiG-21F *et seq*, MiG-23 MiG-27 MiG-29, Yak-28PP, Yak-36, Ya-38, IL-28Sh, IL-102 Mi-4AV, Mi-8T, Mi-24, Ka-25F, Ka-29TB, Ka-50			

deposits of soot inside the launch tubes. The 'single-round' bit does not seem to make sense at first, as there are *eight* launch tubes; actually, however, this means that (as distinct from cannons) the ORO-57K cannot be reloaded in flight. Later the terminology was changed and FFAR pods were rightly called ***mnogozaryadnaya pooskovaya oostanovka*** (multiple launcher). The ORO-57K is 1.44 m (4 ft $8\frac{11}{16}$ in) long, with a maximum diameter of 0 225 m ($8\frac{27}{32}$ in).

Later, the 16-round UB-16-57 and the 32-round UB-32-57 were developed in order to create a more effective salvo when using S-5 rockets. These two pods, which come in a multitude of versions, can be carried by fixed-wing and rotary-wing aircraft alike, hence the UB designator standing for *oon**iversahl'nyy blok*** (versatile [FFAR] pod) For instance, experience with FFAR launches by assault helicopters showed that the rockets were affected by the rotor downwash, which was detrimental to accuracy. Therefore, the special heliborne UB-16-57V version (***vertolyotnyy*** – for helicopters) features extra long launch tubes to enhance the rockets' stability.

The use of FFARs on supersonic aircraft created a problem associated with the S-5KP and S-5KPB whose piezoelectric fuse turned out to be sensitive to kinetic heating at supersonic speeds. To remedy this, the UB-32-O and UB-32M pods have heat-insulated launch tubes; quite simply, the orifices are closed by thin asbestos covers which are expelled by the rockets as they leave the tubes. To prevent a premature explosion the fuses are designed to be armed after the rocket clears the launch pod

Various versions of the S-5 FFAR are still used by many Russian-built combat aircraft and helicopters as of this writing

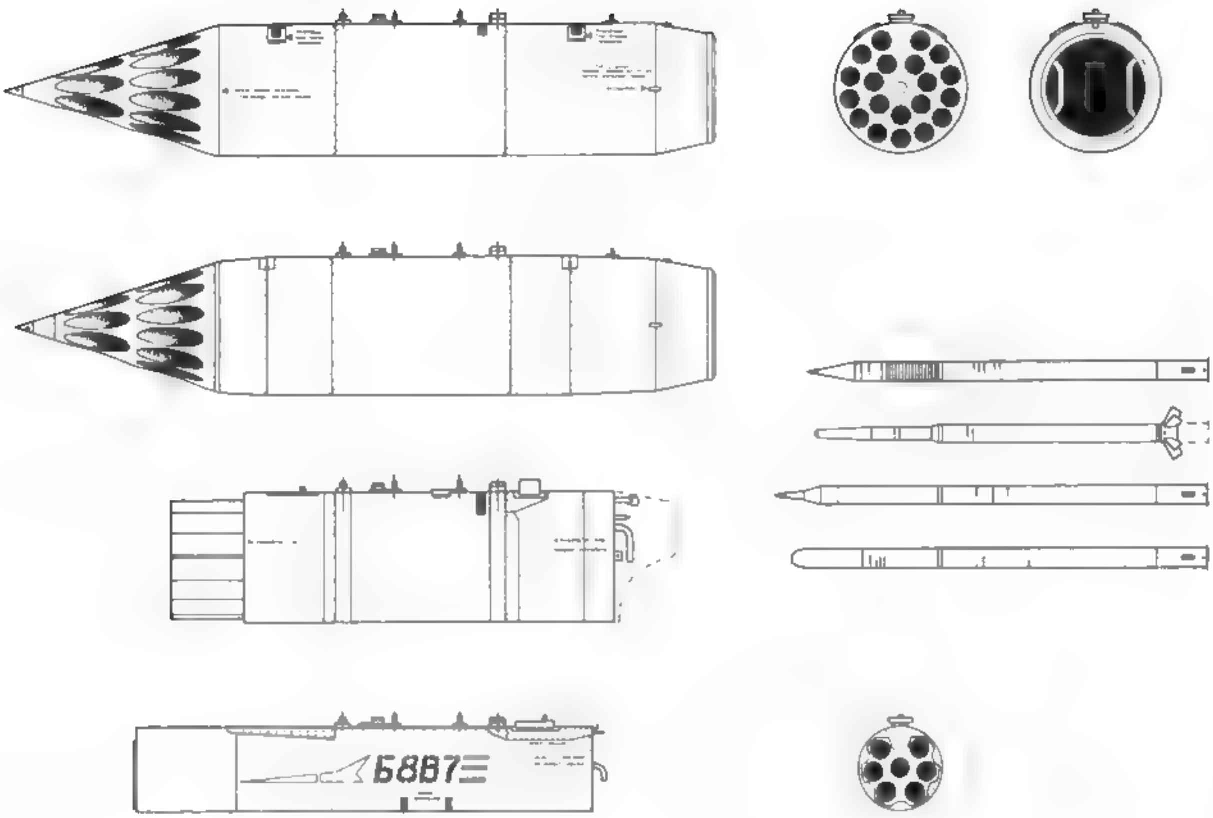
S-8 folding-fin aircraft rocket

The ever-growing capabilities of the potential adversary's battlefield air defences made it imperative to increase the launch range of the S-5 in order to minimise losses among 'friendly' strike aircraft. Another shortcoming of the S-5 was the small warhead, which was especially inadequate against armoured vehicles and hardened structures. On the other hand, an increase in rocket motor power and warhead weight could not be attained without an attendant increase in the rocket's dimensions. Therefore, the S-5's successor designated S-8 had its calibre increased to 80 mm (3.15 in) while retaining the predecessor's general arrangement.

For higher accuracy the six stabilising fins of the S-8 are no longer spring-loaded, they are deployed by a piston actuated by rocket motor bleed gases and locked in position after the rocket leaves the launch tube. (In contrast, the fins of the S-5 have a certain degree of 'play' that leads to deviations from the intended course; Soviet pilots who saw action in Afghanistan said the S-5s were prone to fanning out 'in a tulip-like shape') In pre-launch condition the S-8's fins lie folded forward between the six nozzles of the solid-fuel rocket motor and are enclosed by a cylindrical guard which slips off at the moment of launch. The rocket motor delivers a higher thrust in order to accelerate and spin up the heavier S-8 to the required speed but its burn time is reduced to just 0 69 seconds, the effective launch range is identical to that of the S-5.

The S-8 has an all-purpose fragmentation/armour-piercing warhead designed for use against both armour and personnel

The S-8 is fired from 20-round B-8 pods Fixed-wing aircraft carry the B-8, B-8M or the heat-insulated B-8-O optimised for supersonic flight in the same way as the



Left row, top to bottom: The B-8M1 FFAR pod; the B-8 pod; the heliborne B-8V20A pod; and the B-8V7 pod (carried by, for instance, the Technoavia SM-92P Finist) Right row, top to bottom. Front and rear views of the B-8M1; the S-8KOM; the S-8BM, the S-8DM, the S-8-OM, and a front view of the B-8V7

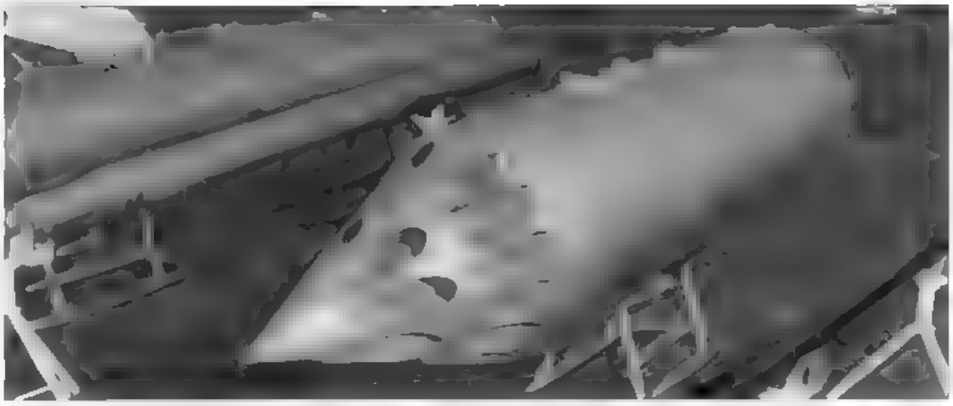
UB-32-O. The B-8V20A heliborne version lacks the conical nose fairing of the other versions, featuring extra long launch tubes instead

The warhead weight of the S-8 is considerably higher as compared to the S-5, and its efficiency is also vastly improved. For instance, a salvo of just twenty S-8 rockets creates the same effect (read: the same amount of death and destruction) as would require the expenditure of no fewer than ninety-six S-5s. Therefore the S-8 is the Russian Air Force's principal unguided rocket of today

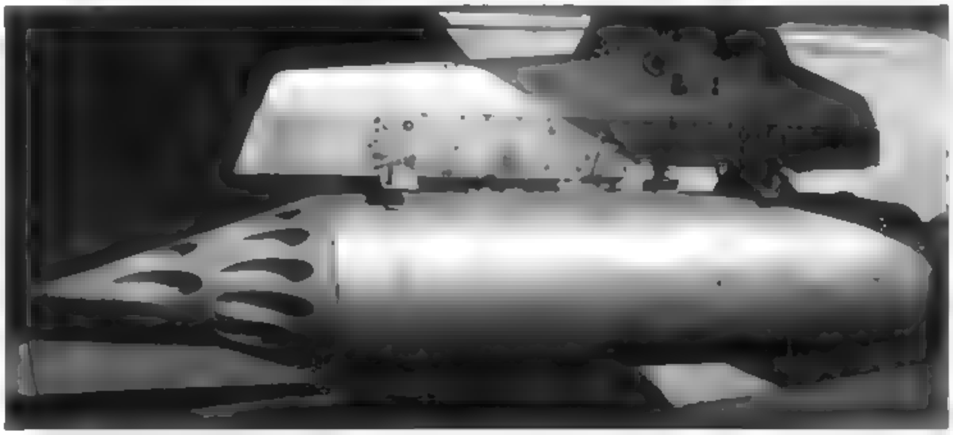
Like the previous model, the S-8 exists in several versions differing in warhead type and rocket motor burn time/thrust. Thus the S-8M, S-8BM, S-8DM, S-8 OM and S-8KOM have a longer-burn rocket motor and accordingly longer range than the versions lacking the M suffix. Additionally, the S-8KOM has a fragmentation/AP warhead with enhanced fragmentation effect and is capable of penetrating armour plate up to 400 mm (15¾ in) thick, while the S-8M has a high-explosive warhead. The S-8S is a flechette rocket filled with 2,000 darts in five bundles; the design of its warhead is similar to that of the S-5S

The S-8B and S-8BM (*betonoboynyy*) have a concrete-piercing warhead that can punch through a layer of reinforced concrete up to 800 mm (2 ft 7½ in) thick. The S-8D and

	S-8KOM	S-8BM	S-8DM	S-8-OM
Service entry	n.a.	n.a.	n.a.	n.a.
Calibre	80 mm (3.14 in)	80 mm (3.14 in)	80 mm (3.14 in)	80 mm (3 14 in)
Length overall	1.54 m (5 ft 1 1/16 in)	1 54 m (5 ft 0⅝ in)	1 7 m (5 ft 6 59/64 in)	1 632 m (5 ft 4¼ in)
Fin span	0.374 m (1 ft 2 23/32 in)	0.374 m (1 ft 2 23/32 in)	0.374 m (1 ft 2 23/32 in)	0 374 m (1 ft 2 23/32 in)
Launch weight kg (lb)	11.3 (24 9)	15.2 (33.5)	11 6 (25.5)	12.1 (26.6)
Warhead weight, kg (lb)	3.6 (7.9)	7 41 (16.33)	3.63 (8.0)	4.3 (9.47)
'Kill' range, km (miles)	1.3-4 (0.8-2 48)	1.2-2.2 (0 74-1 36)	1.3-3 (0.8-1 86)	4-4 5 (2.48-2 79)
Launch pod type	B-8, B-8M. B-8M1, B-8V20A, B-8V7			
Launch platform	Su-17M/Su-22 *et seq*, Su-24, Su-25, Su-27 MiG-23B. MiG-27, MiG-29. Mi-8MT, Mi-24 Ka 25F, Ka-29TB Ka-50			



Right: A B-8M1 pod, showing the asbestos heat insulation plugs in the launch tubes that protect the FFARs against kinetic heating at supersonic speeds.



Below right: A B-8M1 on the port swivelling outer wing pylon of a Su-24 tactical bomber.

S-8DM are fuel/air munitions with a warhead filled with more than 3 kg (4.4 lb) of combustible liquid that creates a cloud of fuel mist, which is then detonated; the demolition effect of one such explosion is equivalent to 6 kg (13.2 lb) of TNT.

The S-8O and S-8OM are 'flare rockets', while the S-8P is a passive ECM rocket filled with chaff. Other versions are the S-8A, S-8V, S-8AS and S-8VS which feature an improved rocket motor using a different grade of fuel and have slightly different fins-cum-actuation mechanism.

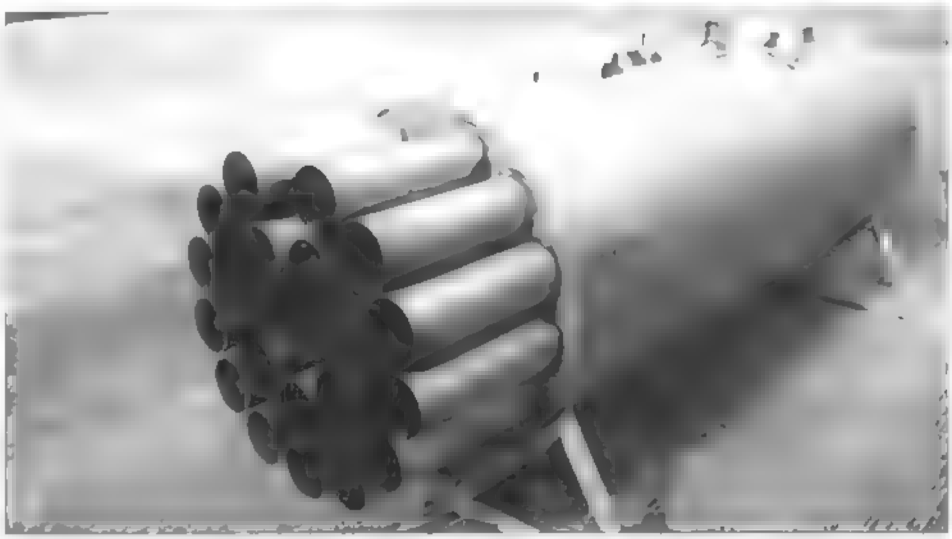
The assorted versions of the S-8 are used by the Su-17 fighter-bomber, the Su-24 tactical bomber, the Su-25 attack aircraft, the Su-27 tactical fighter, the MiG-27 fighter-bomber and other types, as well as the Mil' Mi-8MT transport/assault helicopter, the Mi-24 assault/transport helicopter, the Mi-28 attack helicopter, the Kamov Ka-29TB assault/transport helicopter and the Ka-50 Black Shark attack helicopter.

S-13 folding-fin aircraft rocket

The 122-mm (4.8-in) S-13 heavy HVAR was developed for use against such targets as concrete bunkers and pillboxes, hardened aircraft shelters, runways and the like. Basically it is a scaled-up version of the S-8, featuring improved ballistics and higher accuracy. The baseline version has a length of 2.75 m (9 ft 0¼ in) and a concrete-piercing warhead capable of penetrating a 3-metre (10-ft) layer of earth above a bunker or a layer of reinforced concrete up to 1 m (3 ft 3½ in) thick.

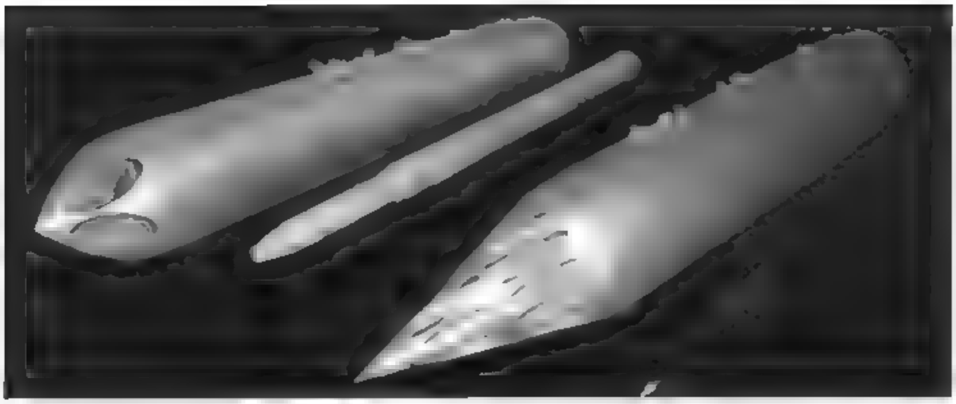
The S-13-OF has an HE/fragmentation warhead generating up to 450 splinters. These are heavy and have sufficient kinetic energy to puncture the hull of a lightly armoured vehicle, such as an armoured personnel carrier or an infantry fighting vehicle, to say nothing of lorries with external armour shields. Overall length is increased to 3.0 m (9 ft 10⅛ in).

The S-13T is a version with enhanced concrete-piercing capability featuring a tandem warhead; the second module explodes inside the target structure after the first module punches through the protective layer of

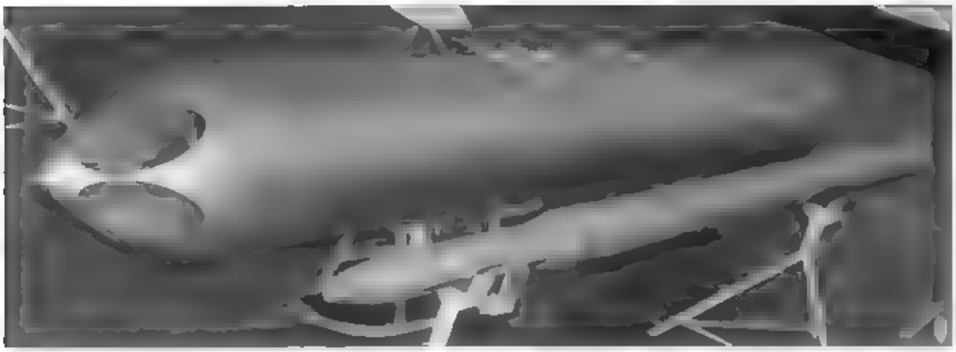


Above right: A B-8V20 pod on display, showing the extra-long exposed launch tubes.

Right: The B-8V20 is typically carried by the Mi-8MT and its derivatives, including this Mi-8AMTSh assault helicopter.



Left: This view illustrates the relative size of the S-13 FFAR (left) and the S-8, as well as their associated B-13L and B-8M pods



Below left: A B-13L pod and an S-13 on display at an airshow. Note that the warhead is of smaller diameter than the rocket's body.

up to 6 m (20 ft) of earth or up to 1 m of reinforced concrete. A single S-13T impacting a concrete runway can obliterate up to 20 m^2 (215 sq ft) of runway surface. Overall length is 3.1 m (10 ft 2 in).

The rockets are carried in B-13L five-round pods and fired at a maximum distance of 3 km (1.86 miles). The B-13L is 3.558 m (11 ft 8 in) long, with a maximum diameter of 0.41 m (1 ft 4¾ in).

To sum up this chapter, it may be said that despite the advent of precision-guided munitions (PGMs), unguided rockets are still very much alive. Their high combat efficiency, simplicity of manufacturing, ease of operational use and good cost/effect ratio allows them to stand their ground against modern, complex and outrageously expensive PGMs.

	S-13	S-13T	S-13-OF
Service entry	n.a.	n.a.	n.a.
Calibre	122 mm (4.8 in)	122 mm (4.8 in)	122 mm (4.8 in)
Length overall	2.75 m (9 ft 0¼ in)	3.1 m (10 ft 2 in)	3.0 m (9 ft 10⅛ in)
Fin span	n.a.	n.a.	n.a.
Launch weight, kg (lb)	60 (132)	75 (165)	69 (152)
Warhead weight, kg (lb)	23 (50) (46.29+35.9)	21+16.3 33 (72.75)	
'Kill' range, km (miles)	1.1-4 (0.68-2.48)	1.1-3 (0.68-1.86)	1.6-3 (1-1.86)
Launch pod type	B-13L	B-13L	B-13L
Launch platform	Su-17M/Su-22 *et seq*, Su-24, Su-25, Su-27, MiG-27, MiG-29, Mi-8MT *et seq*, Mi-24V *et seq*, Mi-28, Ka-29TB, Ka-50, Ka-52		

'09 Blue', the ninth prototype of the Su-25TM (Su-39) advanced strike aircraft, carrying R-60M AAMs, B-13L FFAR pods, cluster bombs, eight-packs of 9M120 Vikhr' (Whirlwind) anti-tank guided missiles and 800-litre (176 Imp gal) PTB-800 drop tanks.

BOMBS AWAY

Bombs are an important class of aircraft weapons. From the early days of aviation they were the primary means of fulfilling military aviation's primary air-to-surface role, being used against both ground targets and ships. Besides spreading death and destruction, they are used for a wide range of special and auxiliary tasks, such as simulation of nuclear explosions, target illumination, dissemination of propaganda literature and route marking.

Over the years the bomb delivery conditions changed as the bombers' (or fighter-bombers') speed grew and the bomb delivery altitude/speed envelope expanded. Thus the minimum drop altitude was sharply reduced in order to offset the progress in anti-aircraft weapons development and improve the chances of penetrating the enemy's air defences. Modern strike aircraft are capable of delivering bombs from just 25-30 m (80-100 ft), flying at supersonic or near-sonic speeds.

The changing bomb delivery conditions created the need for new models and classes of bombs; in particular, braking devices were developed for fitting to both new and existing models of bombs to turn them into retarded bombs. The braking devices (in the form of hinged airbrakes, parachutes or inflatable balloons) slowed the bomb down and increased the curvature of its trajectory, making sure the aircraft could deliver a low-level bomb strike without getting caught by the blast of its own bombs. When developing new models of bombs the designers paid special attention to minimising mission preparation/turnaround time; hence the latest bombs are delivered from the factories with the fuses already in place and ready for hooking up. This has caused the design of the bombs to grow increasingly more complicated.

Bombs can be divided into four types:

- aerodynamically stable free-fall bombs following a ballistic trajectory while their shape remains unchanged;
- retarded bombs with braking devices deployed when a preset time passes after release to alter their shape and increase drag;
- aerodynamically unstable free-fall bombs (these are mainly napalm tanks);
- guided bombs (also known as 'smart bombs'; by analogy, free-fall bombs are referred to as 'dumb' or 'iron' bombs).

Soviet bombs are also divided into four groups according to their body shape and drag coefficient at different speeds:

- 1962-series low-drag bombs with ogival noses (such bombs have designations suffixed M-62 – for instance, FAB-250M-62);
- high-drag bombs with conical noses;
- 1954-series high-drag bombs with conical noses featuring a ballistic ring (such bombs have designations suffixed M-54);
- flat-nosed or blunt-nosed high-drag bombs.

Bombs of all types and groups are further divided into three classes: general-purpose (GP), special-purpose and auxiliary. The GP class comprises high-explosive bombs (the Russian acronym for them is FAB – *foogahsnaya aviabomba*), fragmentation bombs (AO – *oryenteerno-signahl'naya oskol-ochnaya*), HE/fragmentation bombs (OFAB – *oskolochno-foogahsnaya aviabomba*), armour-piercing bombs (BrAB – *broneboynaya aviabomba*), incendiary bombs (ZAB – *zazhigahtel'naya aviabomba*), HE/incendiary bombs (FZAB – *foogahsno-zazhigahtel'naya aviabomba*), shaped-charge anti-tank bombs (PTAB – *protivotahnkovaya aviabomba*) and anti-submarine bombs (PLAB – *protivolodochaya aviabomba*).

Special-purpose bombs include flash bombs (FotAB – *fotograficheskaya aviabomba*, lit. 'photo bomb'), smoke bombs (DAB – *dymovaya aviabomba*), simulation bombs (IAB – *imitatsionnaya aviabomba*), psychological warfare bombs filled with propaganda leaflets and the like (AgitAB – *aghitatsionnaya aviabomba*), practice bombs (P – *prakticheskaya* [*aviabomba*]) and so on.

The auxiliary bombs include flare bombs (SAB – svetyashchaya *aviabomba*), day marker/signal flare bombs (DOSAB – *dnevnaya oriyenteerno-signahl'naya aviabomba*), coloured marker/signal flare bombs (TsOSAB - *tsvetnaya oryenteerno-signahl'naya aviabomba*), night marker/signal flare bombs (NOSAB – *nochnaya oryenteerno-signahl'naya aviabomba*) and maritime marker/signal bombs (OMAB – *oriyenteerno-morskaya aviabomba*).

Guided ('smart') bombs are those with control surfaces and special guidance equipment allowing the bomb's trajectory to be altered in order to place the weapon squarely on the target. Such bombs are currently designated KAB (*korrekteeruyemaya aviabomba*), although the UB designator (*oopravlyayemaya bomba* – controlled bomb) was used originally.

All bombs are divided into 12 calibres. In this case, 'calibre' means the nominal weight to which the bomb's permissible basic dimensions and actual weight correspond, as detailed in the table on page 158.

Specific models of bombs are allocated alphanumeric designations where the letters indicate the purpose (see classification above) and the digits denote the calibre – for example, FAB-500 for a 500-kg (1,102-lb) calibre HE bomb. If the actual weight differs from the calibre by more than 10-15%, it is approximated and added to the digits denoting the calibre after a dash – for example SAB 250-200.

The following identification markings are applied to the painted outer surface of the bomb. The purpose is indicated by coloured bands around the bomb's body. There are also several stencils – digits indicating the calibre and true weight, the manufacturer's serial number, the number of the factory and the bomb's ballistic characteristics, letters indicating the type of explosive, the year of manufacture and specific design details, and other inscriptions. The colour coding bands are applied to the cylindrical portion of the bomb's body immediately aft of the junction with the nose portion. Their colour and number are determined by a regulation adopted in 1963, high-explosive, fragmentation and practice bombs do not carry any colour coding bands.

Most bombs feature lugs for hooking them up to the aircraft; bombs of less than 250 kg (551 lb) calibre have a single lug, while those from 250 kg upwards have two lugs (the distance between them depends on the calibre). Bomblets of less than 25 kg (55 lb) calibre have no lugs and are dropped from submunitions dispensers.

Explanation of Soviet/Russian bomb calibres

Calibre, kg (lb)	Weight, kg (lb)	Overall length	Body diameter	Stabiliser length	Stabiliser span	CG position (distance from nose)	Distance between mounting lugs
1 (2.2)	1 (2.2)	157 mm (6 3/16 in)	50 mm (1 31/32 in)	70 mm (2 3/4 in)	60 mm (2 23/64 in)	57 mm (2 1/4 in)	-
2.5 (5.51)	4 (8.8)	430 mm (1 ft 4 15/16 in)	62 mm (2 7/16 in)	170 mm (6 11/16 in)	90 mm (3 35/64 in)	131 mm (5 5/32 in)	-
10 (22)	15 (33)	665 mm (2 ft 2 3/16 in)	110 mm (4 21/64 in)	196 mm (7 23/32 in)	140 mm (5 1/2 in)	148 mm (5 53/64 in)	-
25 (55)	35 (77)	940 mm (3 ft 1 in)	140 mm (5 1/2 in)	380 mm (1 ft 2 31/32 in)	180 mm (7 in)	375 mm (1 ft 2 49/64 in)	-
50 (110)	65 (143)	1,050 mm (3 ft 5 21/64 in)	240 mm (9 29/64 in)	390 mm (1 ft 3 23/64 in)	280 mm (11 in)	335 mm (1 ft 0 69/64 in)	-
100 (220)	125 (275)	1,150 mm (3 ft 9 9/32 in)	280 mm (11 in)	390 mm (1 ft 3 23/64 in)	345 mm (1 ft 1 37/64 in)	405 mm (1 ft 3 61/64 in)	-
250 (551)	276 (608)	1,500 mm (4 ft 11 1/16 in)	325 mm (1 ft 0 51/64 in)	500 mm (1 ft 7 11/16 in)	445 mm (1 ft 5 33/64 in)	435 mm (1 ft 5 1/8 in)	250 mm (9 27/32 in)
500 (1,102)	525 (1,157)	1,500 mm (4 ft 11 1/16 in)	450 mm (1 ft 5 23/32 in)	500 mm (1 ft 7 11/16 in)	570 mm (1 ft 10 7/16 in)	435 mm (1 ft 5 1/8 in)	250 mm (9 27/32 in)
1,500 (3,306)	1,575 (3,472)	2,840 mm (9 ft 3 13/16 in)	640 mm (2 ft 1 13/64 in)	975 mm (3 ft 2 25/64 in)	795 mm (2 ft 7 19/64 in)	885 mm (2 ft 10 27/32 in)	480 mm (1 ft 6 29/32 in)
3,000 (6,613)	3,150 (6,944)	3,420 mm (11 ft 2 21/32 in)	820 mm (2 ft 8 9/32 in)	1,150 mm (3 ft 9 9/32 in)	1,030 mm (3 ft 4 35/64 in)	1,015 mm (3 ft 3 31/32 in)	480 mm (1 ft 6 29/32 in)
5,000 (11 020)	5,250 (11,574)	3,420 mm (11 ft 2 21/32 in)	1,060 mm (3 ft 5 47/64 in)	1,150 mm (3 ft 9 9/32 in)	1,330 mm (4 ft 4 23/64 in)	1 015 mm (3 ft 3 31/32 in)	480 mm (1 ft 6 29/32 in)
9 000 (19,840)	9,500 (20,943)	5,085 mm (16 ft 8 13/64 in)	1,200 mm (3 ft 11 1/4 in)	1,900 mm (6 ft 2 51/64 in)	1,510 mm (4 ft 11 29/64 in)	1 480 mm (4 ft 10 17/64 in)	1.000 mm (3 ft 3 3/8 in)

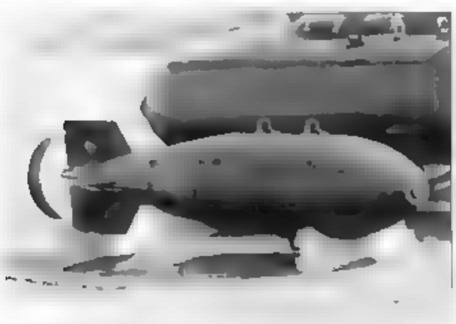
The bombs' stabilisers come in several standardised forms: fin-type, box-type, annular and fin-annular. The stabilisers may be equal in span to the body diameter or have a greater span. Another type of stabilising device found on some bombs (in particular, the Soviet M-54 series) is the ballistic ring on the nose fairing. The ring has the same diameter as the body, it is formed by two conical surfaces, the forward one being set at 72° to the bomb's axis and the rear one at 18° At transonic speeds the ballistic ring acts as a vortex generator, improving the efficiency of the bomb's stabiliser

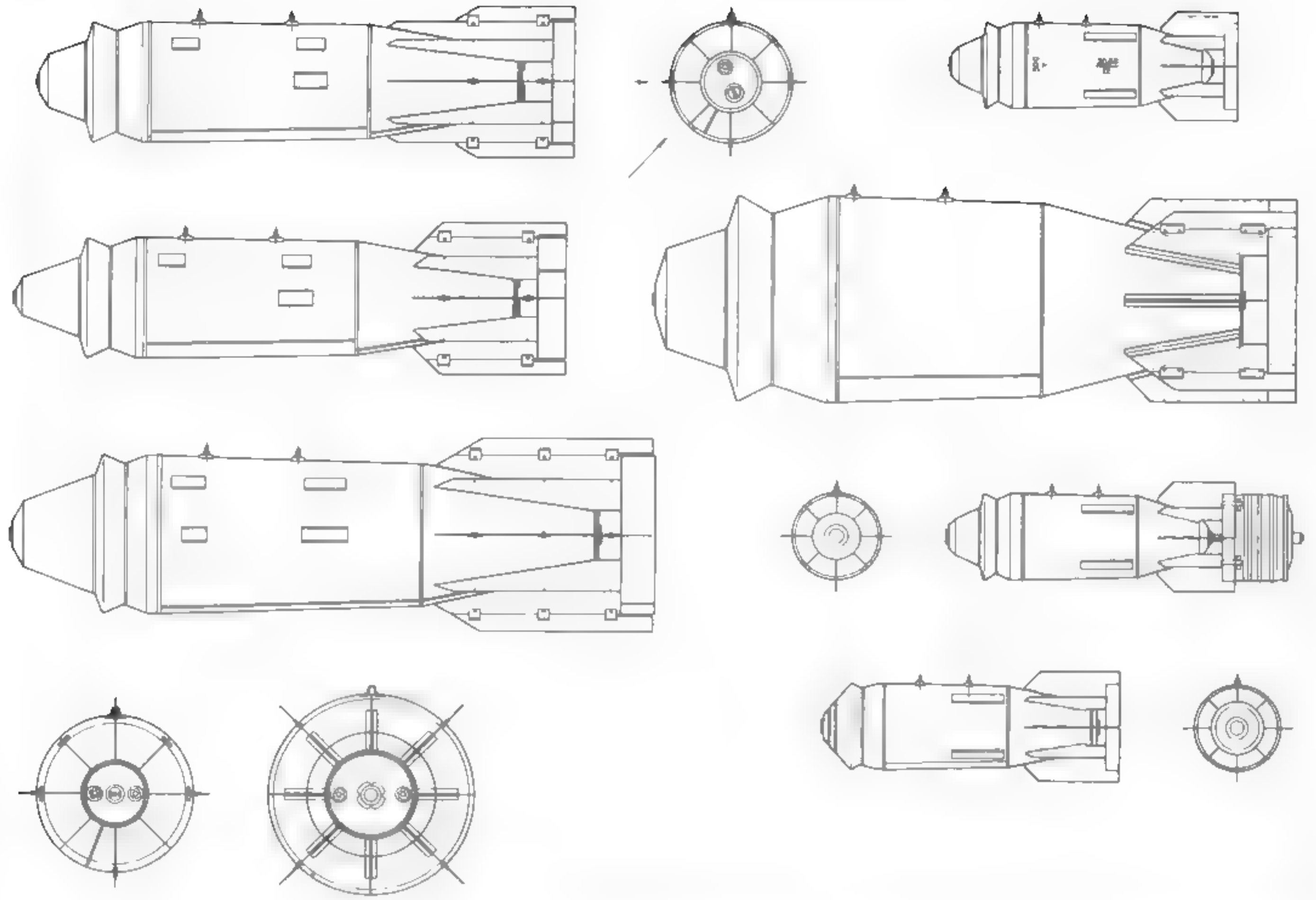
High-explosive bombs

HE bombs destroy the target by the rapid expansion of the combustion products (if

Right: 'Tetris of Death'. This view of FAB-250M-54 high-drag bombs shows the stabiliser design, the twin mounting lugs and ballistic ring

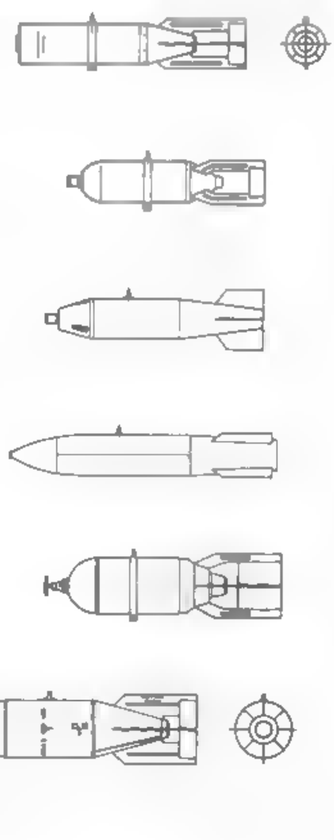
Below: An FAB-250M-62 low-drag bomb.





Above, left row, top to bottom:
The FAB-1500M-54, the FAB-1500-2600TS, the FAB-3000M-54, rear views of the FAB-3000M-54 and FAB-5000M-54.

Above, right row, top to bottom.
The FAB-500M-54, the FAB-53000M-54, a FAB-500M-54 with a TU-500M-54 parabrake, and the FZAB-500M-54

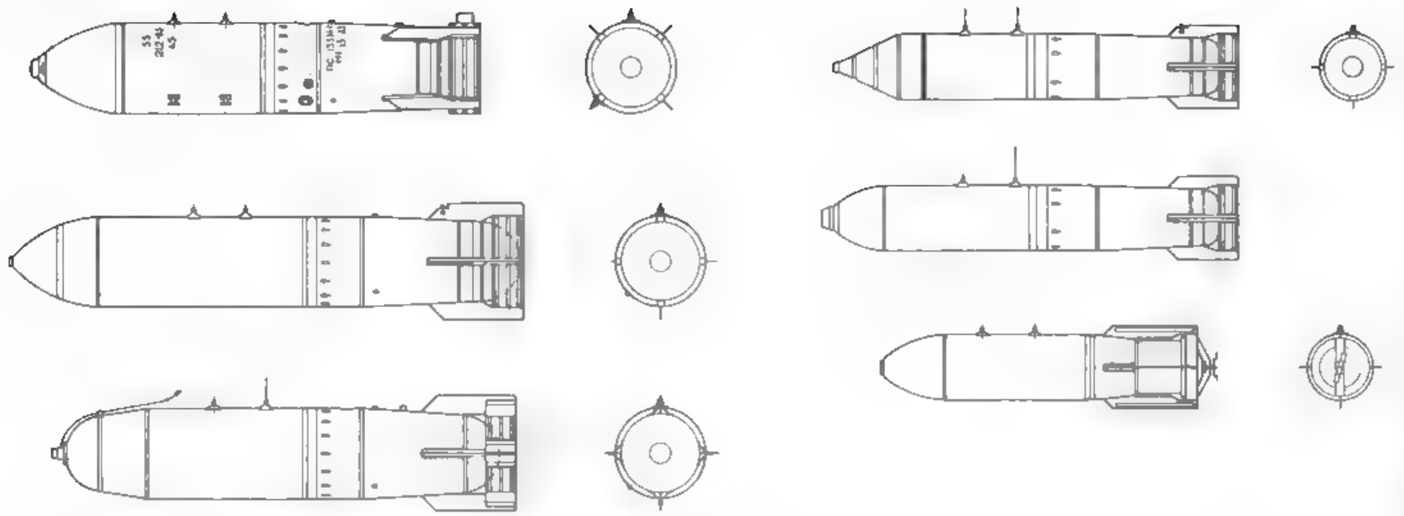


Right, top to bottom:
The FAB-50, the P-50 practice bomb, the P-50Sh practice bomb, the KP-100 concrete practice bomb, the ZAB-100-65-TSh incendiary bomb and the OFAB-100.

the bomb explodes inside the target) or by the blast wave. Such bombs have a calibre of at least 250 kg An HE bomb consists of a welded steel body, a tailcone carrying the stabiliser, nose and base fuse housings, additional detonators and an explosive charge. The body may consist of a nose fairing, a cylindrical centre portion and a base, to the latter is welded the tailcone and the stabiliser

1962-series low-drag HE bombs have an elongated cigar-shaped body; the shape ensures high stability throughout the bomb's travel speed range (right up to supersonic speeds) and reduces the aircraft's overall drag while the bombs are on the wing. Thus the low-drag bombs impose no restrictions on the bomber's flight level and speed during the attack. This series comes in only two calibres – 250 kg (FAB-250M-62) and 500 kg (FAB-500M-62); both models are of identical design, featuring a single nose-mounted fuse and a stabiliser consisting of four fins and a ring.

1954-series high-drag bombs with a ballistic ring show adequate stability throughout the travel speed range. Due to their relatively small size (as compared to 1962-series bombs) they are mostly carried internally This series was manufactured in six calibres ranging from 250 kg (FAB-250M-54) to 9,000 kg (FAB-9000M-54; see table on page 158). The three smallest calibres have one nose fuse and one base fuse; the other three feature three fuses (one nose fuse and two base fuses). 250- and 500-kg bombs have stabilisers consisting of four main fins with a span exceeding the body diameter, four auxiliary fins with a span equal to the body diameter and two concentric rings; the heavier models have eight main fins, four auxiliary fins and two concentric rings.



Above, left row, top to bottom:
The FAB-500ShN, the FAB-500ShR and the FAB-500Sh

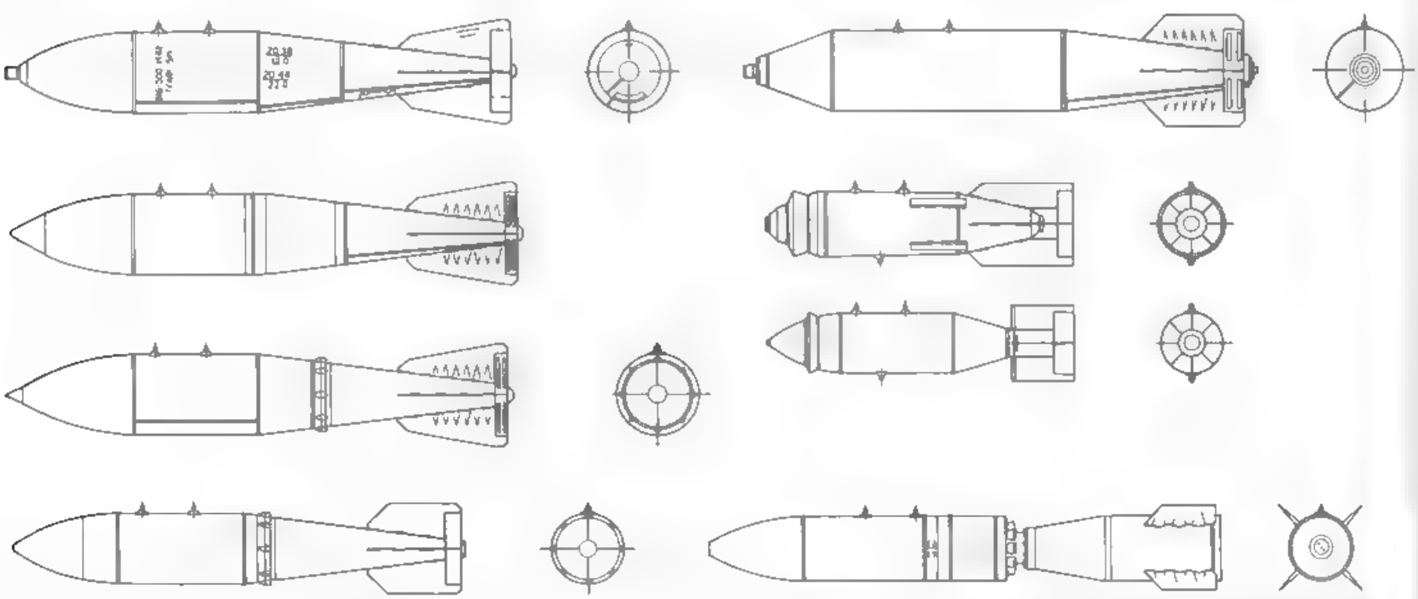
Above, right row, top to bottom:
The OFAB-500ShN, the OFAB-500ShR and the OFAB-250Sh.

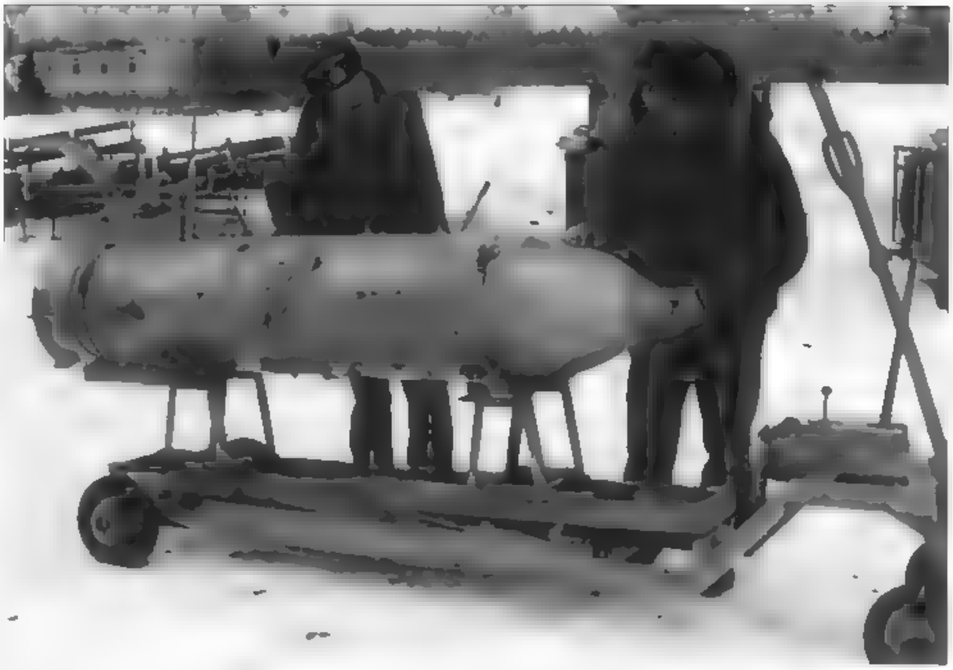
1946-series high-drag bombs exhibit poor ballistic characteristics at transonic speeds and have insufficient body strength. This puts a limit on the aircraft's flight level and speed during the bombing run; M-46 series bombs can be dropped at up to 12,000 m (39,370 ft) and 1,000 km/h (621 mph). Therefore, an interim version with thicker walls and no nose fuse was produced until the M-54 series appeared. The M-46 series came in four sizes (FAB-250M-46, FAB-500M-46, FAB-1500M-46 and FAB-3000M-46). These bombs had one nose fuse and one base fuse: the fin-annular stabiliser with a span matching the body diameter comprised four main fins, four auxiliary fins and three concentric rings. 250- and 500-kg bombs manufactured until 1956 had five lugs set 250 mm ($9\frac{27}{32}$ in) and 356 mm (1 ft 2 in) apart, enabling them to be carried by aircraft fitted with both current and old (World War Two-vintage) bomb shackles.

The thick-walled version of the M-46 series has a greatly reinforced body where the nosecone and centre portion are manufactured as one, with no aperture for a nose fuse. Such bombs were manufactured in three calibres: 250 kg, 500 kg and 1,500-2,600 kg (3,306-5,730 lb). The 250- and 500-kg versions have fin-annular stabilisers consisting of four main fins with a span exceeding the body diameter, four auxiliary fins and two concentric rings; the heavier models have two base fuses and stabilisers with eight main fins with a span exceeding the body diameter, four auxiliary fins and two concentric rings. Thick-walled M-46 series bombs manufactured until 1956 had the two standard lugs augmented by a third, the front and rear lugs being 356 mm apart, for

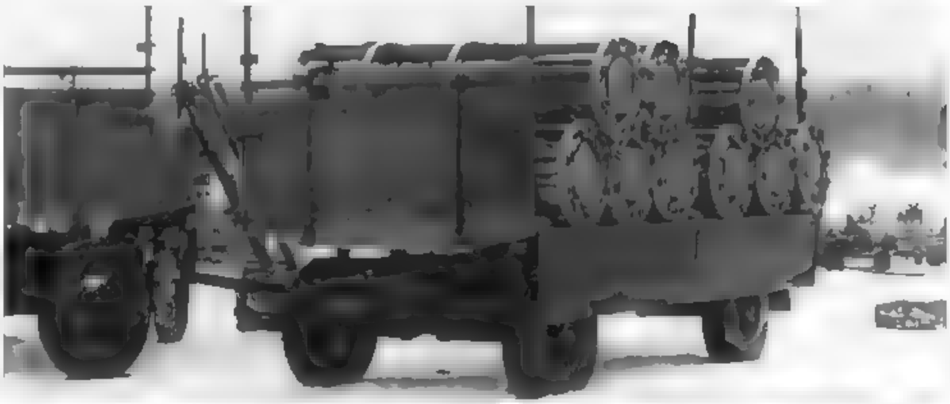
Below, left row, top to bottom:
The FAB-500M-62 (FAB-500M-62T), the FAB-500M, the FAB-500 (FAB-500TA) and the BetAB-500 concrete-piercing bomb.

Below, right row, top to bottom:
The AgitAB-500-300 psy-war bomb, the FAB-250M-54, the FAB-250TS and the BetAB-500ShP rocket-propelled concrete-piercing bomb





Right: Russian Air Force armourers prepare an OFAB-500ShN parachute-retarded bomb optimised for low-level operations. The bomb rests on a ground handling dolly/bomb lift.



Below right: OFAB-500ShN bombs in special cage-like crates on a trailer manufactured by the East German company IFA.

carriage by older aircraft; such bombs had designations suffixed TS (for example, FAB-250TS)

In addition to these three series, there was the FAB-2000 which does not fit into the classification system described above. This 2,000-kg (4,410-lb) calibre bomb had one nose fuse and one base fuse, the stabiliser consisted of four main fins with a span exceeding the body diameter, which were connected by angle pieces and reinforced by 12 auxiliary fins or struts. The bomb was 4,652 mm (15 ft 3 5/32 in), with a body diameter of 600 mm (1 ft 11 5/8 in) and a stabiliser span of 840 mm (2 ft 9 in); the actual weight was 2,126 kg (4,687 lb)

As the bomb parts company with the shackle, a special electric cable connected to the aircraft passes an electric impulse, activating the fuse's remote safety mechanism which is disabled when a certain time passes. The fuse is now ready for action, detonating the primer and the main charge as the bomb hits

Bombs intended for low-level strikes against well-protected enemy strongholds, airfields, factory buildings and the like feature a special fitting increasing the impact force acting on the fuse to make sure it detonates the bomb, the fitting is enclosed by a crushable fairing. Such bombs are retarded bombs with braking devices which slow the bomb down and increase the curvature of its trajectory, preventing the aircraft from being struck by the splinters of its own bombs. The fuse is activated by the deployment of the braking device, if the latter fails, the fuse's safety feature will not be disabled and the bomb will not explode Such bombs have designations suffixed Sh (FAB-500Sh etc) to denote *shtoormovaya* (for ground-attack or strike missions). Retarded bombs can be delivered at 770-1,500 km/h (478-931 mph) from altitudes of 85-500 m (280-1,640 ft)

Other suffix letters used in model designations have the following meaning The T suffix in the FAB-500M-62T designation denotes *termostoykoye vzryvchatoye veshchestvo* (heat-resistant explosive)

Right: The OFAB-500ShL HE/fragmentation retarded bomb.

Far right: The smaller The OFAB-250ShL; the 'fat tail' houses the parabraking device.

Type 1 high-explosive bombs

	FAB-9000M-54	FAB-5000M-54	FAB-3000M-54	FAB-1500T	FAB-1500-2600TS	FAB-1500M-54	FAB-500M-62
Overall length	5,000 mm (16 ft 4 27/32 in)	3,324 mm (10 ft 10 55/64 in)	3,320 mm (10 ft 10 45/64 in)	3,533 mm (11 ft 7 in)	2,840 mm (9 ft 3 13/16 in)	2,765 mm (9 ft 0 55/64 in)	2,229 mm (7 ft 3 3/4 in)
Body diameter	1,200 mm (3 ft 11 1/4 in)	1,060 mm (3 ft 5 47/64 in)	820 mm (2 ft 8 9/32 in)	580 mm (1 ft 10 53/64 in)	630 mm (2 ft 1 13/16 in)	630 mm (2 ft 1 13/16 in)	400 mm (1 ft 3 3/4 in)
Stabiliser span	1,504 mm (4 ft 11 7/32 in)	1,330 mm (4 ft 4 23/64 in)	1,002 mm (3 ft 3 29/64 in)	780 mm (2 ft 6 45/64 in)	792 mm (2 ft 7 3/16 in)	792 mm (2 ft 7 3/16 in)	515 mm (1 ft 8 9/32 in)
Weight, kg (lb)	9,412 (20,750)	5,252 (11,578)	3,067 (6,761)	1,519 (3,348)	2,587 (5,703)	1,551 (3,419)	497 (1,095)

Type 1 high-explosive bombs (continued)

	FAB-500M-54	FAB-500M-46	FAB-250M-62	FAB-250M-54	FAB-250M-46	FAB-1500M-46	FAB-3000M-46
Overall length	1 500 mm (4 ft 11 3/64 in)	1,500 mm (4 ft 11 3/64 in)	1,924 mm (6 ft 3 3/4 in)	1,500 mm (4 ft 11 3/64 in)	1,500 mm (4 ft 11 3/64 in)	2 763 mm (9 ft 0 25/32 in)	3,332 mm (10 ft 11 3/16 in)
Body diameter	450 mm (1 ft 5 23/32 in)	450 mm (1 ft 5 23/32 in)	300 mm (11 13/16 in)	325 mm (1 ft 0 51/64 in)	325 mm (1 ft 0 51/64 in)	630 mm (2 ft 1 13/16 in)	820 mm (2 ft 8 9/32 in)
Stabiliser span	570 mm (1 ft 10 7/16 in)	450 mm (1 ft 5 23/32 in)	370 mm (1 ft 2 9/16 in)	410 mm (1 ft 4 9/64 in)	325 mm (1 ft 0 51/64 in)	630 mm (2 ft 1 13/16 in)	820 mm (2 ft 8 9/32 in)
Weight, kg (lb)	477 (1,051)	426 (939)	229 (505)	239 (527)	221 (487)	1,476 (3,254)	3,001 (6,615)

Type 2 (retarded) high-explosive bombs

	FAB-1500Sh	FAB-500Sh	FAB-500M-54 with parabrake	FAB-250M-54 with parabrake
Overall length	2 598 mm (8 ft 6 9/32 in)	2,210 mm (7 ft 3 in)	1,793 mm (5 ft 10 19/32 in)	1,823 mm (5 ft 11 49/64 in)
Body diameter	630 mm (2 ft 1 13/16 in)	450 mm (1 ft 5 23/32 in)	450 mm (1 ft 5 23/32 in)	325 mm (1 ft 0 51/64 in)
Stabiliser span	794 mm (2 ft 7 17/64 in)	570 mm (1 ft 10 7/16 in)	570 mm (1 ft 10 7/16 in)	410 mm (1 ft 4 9/64 in)
Weight, kg (lb)	1,517 (3,344)	515 (1,135)	503 (1,109)	255 (562)

These low-drag bombs are carried by the Mikoyan/Gurevich MiG-25RB supersonic reconnaissance/strike aircraft and have to be capable of withstanding the immense kinetic heating at Mach 2+ to make sure they will not blow the aircraft to bits before it reaches the target

The A suffix of the FAB-1500ShA retarded bomb means that the bomb has a so-called active jacket – a hollow cylinder inserted into the metal body and filled with explosive. The jacket is combustible and its combustion generates a considerable amount of heat, significantly increasing the demolition effect

The FAB-1500DS PZ is actually a fuel/air bomb with enhanced demolition effect, despite the FAB designator (such bombs are usually designated ODAB – see below); the meaning of the suffix is unknown In the case of the FAB-1500M-54MS and FAB-3000M-54TGA the final suffix letters indicate the type of explosive used, and so on

High-explosive/fragmentation bombs

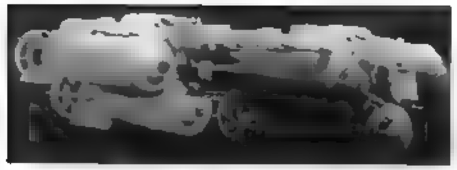
High-explosive/fragmentation bombs are designed for use against such targets as lightly armoured vehicles, artillery weapons, radars and personnel. Such bombs are similar to HE bombs but the steel body is hatched on the inside to facilitate formation of splinters whose penetration effect augments the demolition effect of the explosive HE/fragmentation bombs have a calibre of up to 500 kg

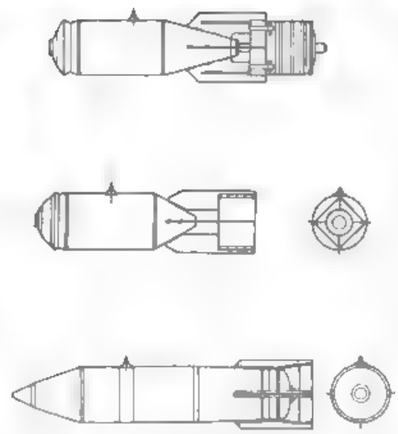
To increase the lethal effect of the splinters an HE/fragmentation bomb is detonated in mid-air about 0.5-1.5 m (1.6-5 ft) above the target This is achieved by means of a stand-off detonation device – a telescopic boom with a carefully calculated length tipped with an impact fuse located on the bomb's axis The bomb is equipped with a parabrake whose deployment triggers the extension of the telescopic detonation device.

The designations of HE/fragmentation bombs are generally similar to those of HE bombs but have a few peculiarities (that is, suffix letters unique to this class). Thus, the OFAB-100M (*modernizeerovannaya*) is upgraded to take a specific model of fuse The OFAB-100NV features a proximity fuse (hence the NV for *nekontaktnyy vzryvahtel'*), while the OFAB-100-125TEU has a telescopic detonation device with an electro-pyrotechnical detonator. The OFAB-100ShN (*shtoormovaya, nizkovysotnaya* – for low-level strike missions) is optimised for use at low altitudes (50-500 m/164-1,640 ft); the OFAB-100ShR has multiple warheads (*razdelyayushchiyesya boyevyye chasti*) almost like an intercontinental ballistic missile, and so on

Fragmentation bombs

Fragmentation bombs have the same applications as HE/fragmentation bombs but their main effective factor is splinters generated when the thick-walled body is shattered by a relatively small explosive charge. Such bombs are mostly small, with a calibre of up to 50 kg, and come in widely varying shapes.



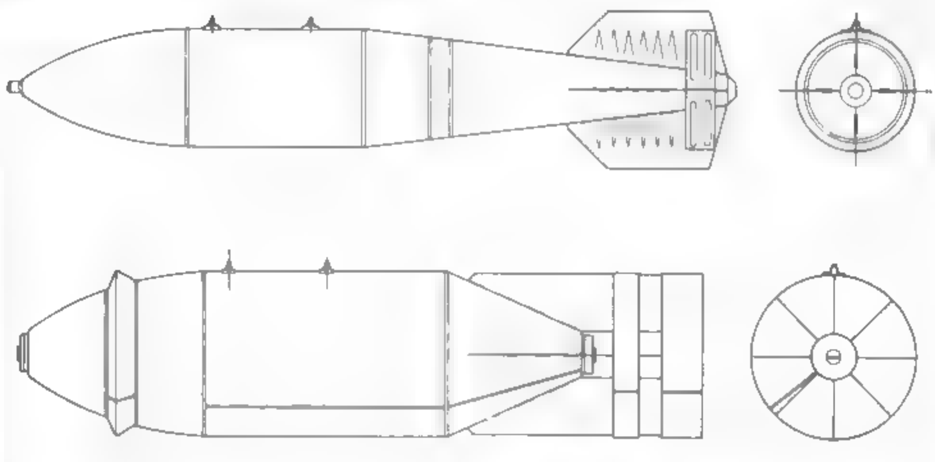


Above: FAB-100 bombs on an MBD3-U6-68 multiple ejector rack under the wing of the Sukhoi S-32M2D prototype.

Top right: Close-up view of the MBD3-U6-68 with FAB-100 bombs.

Above right, top to bottom: An OFAB-100-120 fitted with a TU-100-120 parabraking device; the OFAB-100M; the OFAB-100T

Right: The FAB-1500T (above) and the FAB-3000M-46.



Below: The MiG-23ML fighter was used mainly for strike duties in the Afghan War. This one is configured with sixteen FAB-100 bombs on MBD3-U4-68 MERs

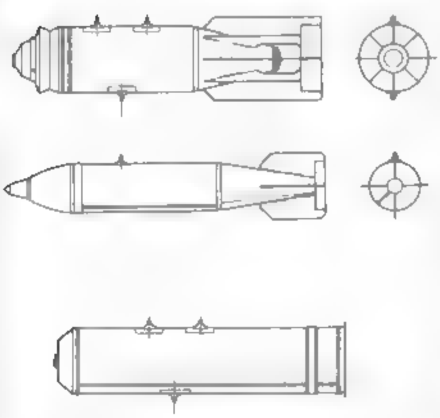
Below right: Another MiG-23ML in action in Afghanistan, this time with two FAB-250s and two FAB-500s.

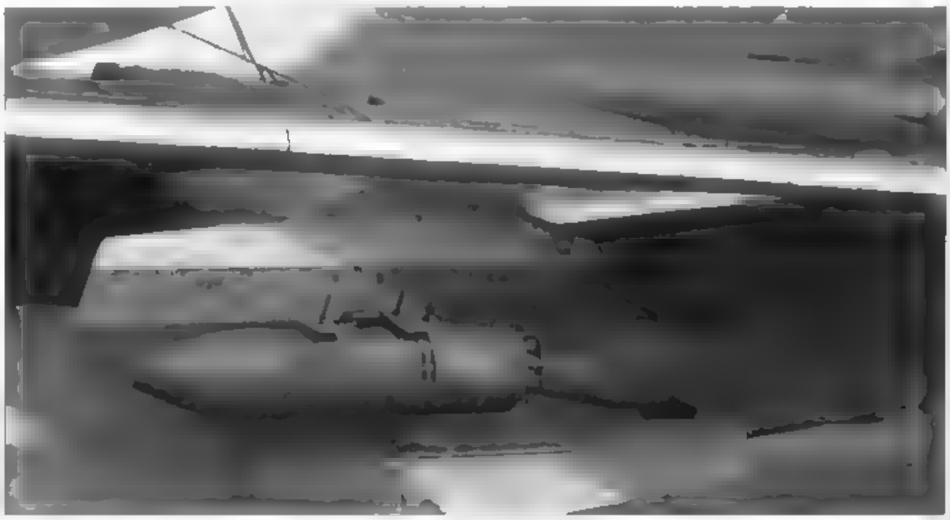
Type 1 high-explosive/fragmentation bombs

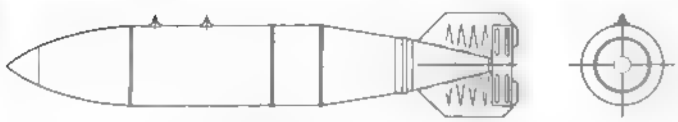
	OFAB-250T	OFAB-250-270	OFAB-100-120	OFAB-100-125TU	OFAB-100M
Overall length	2,050 mm (6 ft 8 45/64 in)	1,456 mm (4 ft 9 21/64 in)	1,060 mm (3 ft 5 47/64 in)	1,104 mm (3 ft 7 15/32 in)	1,060 mm (3 ft 5 47/64 in)
Body diameter	300 mm (11 13/16 in)	325 mm (1 ft 0 51/64 in)	273 mm (10 3/4 in)	280 mm (11 in)	280 mm (11 in)
Stabiliser span	380 mm (1 ft 2 31/32 in)	410 mm (1 ft 4 9/64 in)	345 mm (1 ft 1 37/64 in)	345 mm (1 ft 1 37/64 in)	310 mm (1 ft 0 ¾ in)
Weight, kg (lb)	239 (527)	270 (595)	125 (275)	125 (275)	121 (266)

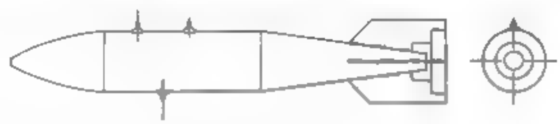
Type 2 (retarded) high-explosive/fragmentation bombs

	OFAB-500ShR	OFAB-250ShN	OFAB-100T	OFAB-250-270 with parabrake	OFAB-100-120 with parabrake
Overall length	2,493 mm (8 ft 2 5/32 in)	1,990 mm (6 ft 6 11/32 in)	1,496 mm (4 ft 10 29/32 in)	1,751 mm (5 ft 8 15/16 in)	1,301 mm (4 ft 3 7/32 in)
Body diameter	450 mm (1 ft 5 23/32 in)	325 mm (1 ft 0 51/64 in)	280 mm (11 in)	325 mm (1 ft 0 51/64 in)	273 mm (10 3/4 in)
Stabiliser span	570 mm (1 ft 10 7/16 in)	410 mm (1 ft 4 9/64 in)	345 mm (1 ft 1 37/64 in)	410 mm (1 ft 4 9/64 in)	345 mm (1 ft 1 37/64 in)
Weight, kg (lb)	525 (1,157)	268 (590)	119 (262)	288 (635)	138 (304)



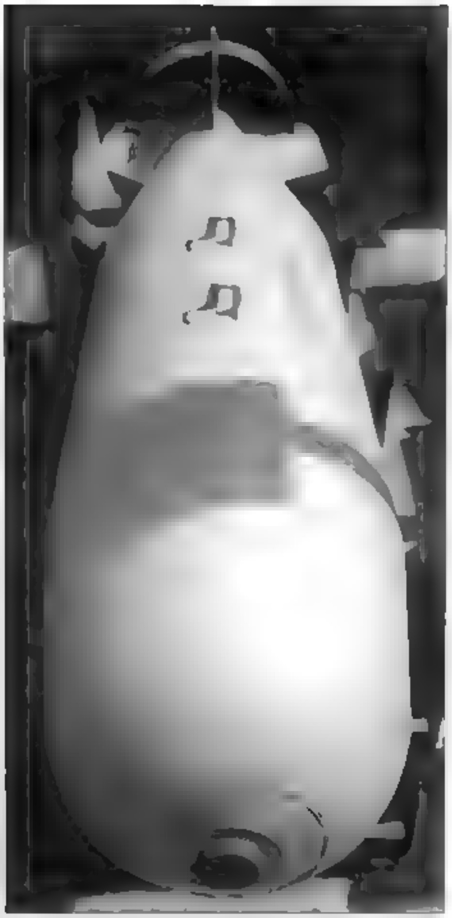


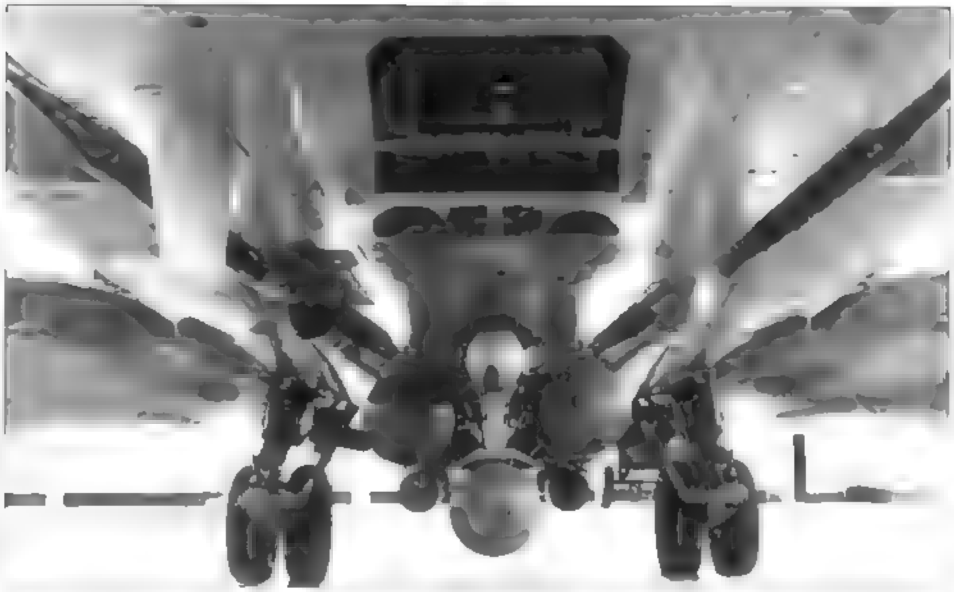


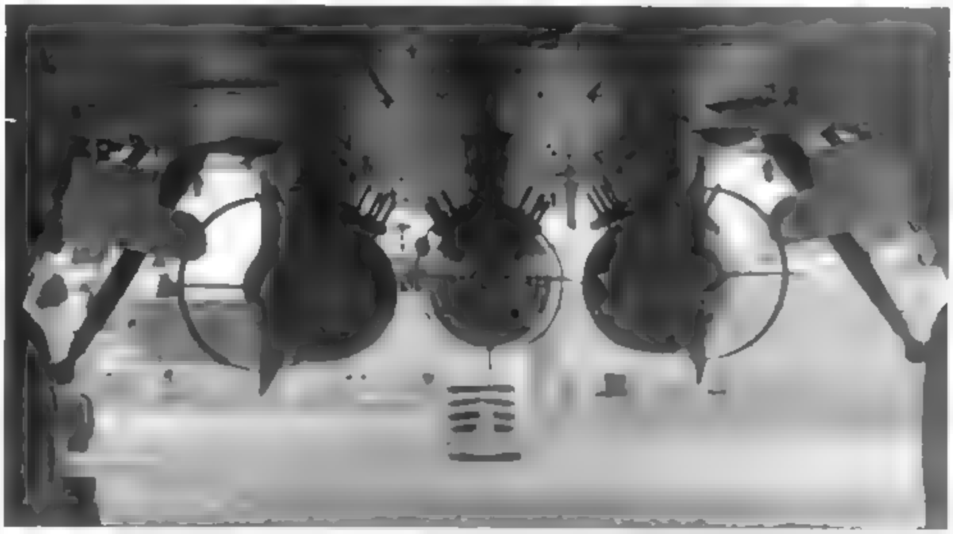


Fragmentation bombs

	AO-2,5RT	AO-2,5SCh	AO-10SCh	AO-25-33	AO-50-100M
Overall length	150 mm (5 29/32 in)	378 mm (1 ft 2 57/64 in)	385 mm (1 ft 3 5/32 in)	987 mm (3 ft 2 55/64 in)	1,063 mm (3 ft 2 55/64 in)
Body diameter	90 mm (3 35/64 in)	52 mm (2 in)	90 mm (3 35/64 in)	122 mm (4 13/16 in)	204 mm (8 in)
Stabiliser span	115 mm (4 17/32 in)	60 mm (2 23/64)	120 mm (4 47/64 in)	122 mm (4 13/16 in)	280 mm (11 in)
Weight, kg (lb)	2.44 (5.38)	2.7 (5.95)	8.9 (19.62)	33 (72.75)	96 (211)







Above: The OFZAB-500 high-explosive/ fragmentation/incendiary bomb.

Above right. FAB-100s on an MBD3-U6-68 MER under a Su-24 tactical bomber.

Right: FAB-500M-62 low-drag bombs under a Su-24M.

Left: A BetAB-500ShP concrete-piercing bomb on the outer wing pylon of a Su-24M

Far left, top to bottom: Te FotAB-250-215 flash bomb, the FotAB-100-140, The ZAB-250-130V incendiary bomb; the ZAB-500V.

Below left: The FotAB-250T flash bomb.

For example, the AO-1 bomblet of 1-kg (2.2-lb) calibre has a detachable stabiliser with fins cut away from the inside to accommodate the nose of another bomblet, allowing more submunitions to be packed into a dispenser pod. The AO-1M is nothing less than a converted anti-personnel mine. The AO-2,5SCh of 2.5-kg (5 5-lb) calibre has a body made of semi-steel (toughened cast iron, hence the SCh suffix for ***stalistyy chugoon***) and a fuse with a propeller-like vane deactivating the safety feature when the bomblet is dropped

The ShOAB-0,5 pellet bomb (***sharikovaya oskolochnaya avia-bomba***) has a spherical body of 60 mm (2²⁵⁄₆₄ in) diameter filled with 304 round pellets of 5.5 mm (⁷⁄₃₂ in) diameter. These bomblets are used as submunitions in cluster bombs

This category also includes air-droppable mines, such as the MA-3 submunition (*mina aviatsionnaya*), a finless barrage mine designed for mining airfields from the air, cutting off avenues of approach for enemy troops and so on. Its body is a section of steel pipe sealed at one end; the fuse is armed when the mine hits the ground and the mine explodes when run over by a vehicle or trodden on by a 'soldier of misfortune As the calibre increases, the fragmentation bombs assume the classic shape a bomb should have

Incendiary (HE/incendiary) bombs and napalm tanks

Incendiary bombs and napalm tanks are designed for setting fire to buildings and destroying personnel. Their penetration capability is low and their action is confined to the surface of the target. HE/incendiary bombs destroy the target with the blast wave before setting it alight

When an incendiary bomb is dropped the nose fairing is jettisoned. On impact the fuse detonates an explosive charge which breaks open a canister filled with white phosphorus whose contents are thus mixed with a burning mixture filling the bomb's body. When the bomb's body bursts, the contents ignite

Napalm tanks (designated ZB – ***zazhigahtel'nyy bahk***, 'incendiary tank') are filled with a gelatinous burning mixture capable of adhering to various surfaces. The tank is ruptured by a fuse on impact, whereupon the mixture self-ignites

The burning mixtures create a temperature of at least 800-1,000°C (1,472-1,832°F) and huge flames as they burn; they possess a certain viscosity and are difficult to put out, making sure a massive fire is started Incendiary bombs are filled with metal-based or petroleum-based burning mixtures The former type comprises termite mixtures (aluminium mechanically mixed with iron oxide acting as an oxidiser) and mixtures of metals with other oxidisers

Type 1 incendiary bombs

	FZAB-500M	FZAB-500	ZAB-500V	ZAB-500Sh	ZAB-500-400
Overall length	2,499 mm (8 ft 2 25/64 in)	1,530 mm (5 ft 0 15/64 in)	2,490 mm (8 ft 2 in)	1,925 mm (6 ft 3 25/32 in)	1,496 mm (4 ft 10 29/32 in)
Body diameter	400 mm (1 ft 3 3/4 in)	450 mm (1 ft 5 23/32 in)	400 mm (1 ft 3 3/4 in)	450 mm (1 ft 5 23/32 in)	450 mm (1 ft 5 23/32 in)
Stabiliser span	515 mm (1 ft 8 9/32 in)	570 mm (1 ft 10 7/16 in)	515 mm (1 ft 8 9/32 in)	568 mm (1 ft 10 23/64 in)	570 mm (1 ft 10 7/16 in)
Weight, kg (lb)	501 (1,104)	496 (1,093)	399 (879)	428 (943)	407 (897)

Type 1 incendiary bombs (continued)

	ZAB-250-200	ZAB-100-105	ZAB-100SK	ZAB-2,5S	ZAB-2,5T
Overall length	1,500 mm (4 ft 11 3/64 in)	1,065 mm (3 ft 5 59/64 in)	1,065 mm (3 ft 5 59/64 in)	145 mm (5 45/64 in)	245 mm (9 41/64 in)
Body diameter	300 mm (11 13/16 in)	273 mm (10 3/4 in)	273 mm (10 3/4 in)	90 mm (3 35/64 in)	64 mm (2 33/64 in)
Stabiliser span	410 mm (1 ft 4 9/64 in)	345 mm (1 ft 1 37/64 in)	345 mm (1 ft 1 37/64 in)	-	-
Weight, kg (lb)	197 (434)	108 (238)	106 (233)	2.5 (5.5)	2.5 (5 5)

Type 3 incendiary bombs (napalm tanks)

	ZB-500	ZB-500AS	ZB-500ShM	ZB-360	ZB-250Sh
Overall length	2,860 mm (9 ft 4 39/64 in)	2,833 mm (9 ft 3 17/32 in)	2,503 mm (8 ft 2 35/64 in)	2,616 mm (8 ft 7 in)	1,776 mm (5 ft 9 59/64 in)
Body diameter	500 mm (1 ft 7 11/16 in)	500 mm (1 ft 7 11/16 in)	500 mm (1 ft 7 11/16 in)	500 mm (1 ft 7 11/16 in)	325 mm (1 ft 0 51/64 in)
Stabiliser span	700 mm (2 ft 3 9/16 in)	–	–	750 mm (2 ft 5 17/32 in)	–
Weight, kg (lb)	357 (787)	325 (716)	306 (674)	345 (760)	115 (253)

Type 1 flash bombs

	FotAB-250T	FotAB-250-215	FotAB-100-140	FotAB-100-80
Overall length	2,125 mm (6 ft 11 21/32 in)	1,500 mm (4 ft 11 3/64 in)	1,600 mm (5 ft 3 in)	1,052 mm (3 ft 5 27/64 in)
Body diameter	300 mm (11 13/16 in)	325 mm (1 ft 0 51/64 in)	240 mm (9 29/64 in)	280 mm (11 in)
Stabiliser span	415 mm (1 ft 4 11/32 in)	410 mm (1 ft 4 9/64 in)	335 mm (1 ft 1 3/16 in)	310 mm (1 ft 0 13/64 in)
Weight, kg (lb)	275 (474)	213 (470)	141 (310)	78 (172)

Termite mixtures generate a temperature of up to 3,000°C (3,432°F); they burn without a flame (that is, without gaseous combustion products) and cannot be extinguished by water. Termite mixtures create a pool of liquid metal slag which spreads, increasing the area of the fire

The Soviet/Russian Air Force inventory included the following main types of incendiary bombs: ZAB-2,5, ZAB-100-105, ZAB-100-114, ZAB-250-130V, ZAB-250-200, ZAB-500-350, ZAB-500-400 and others

Flash bombs

Flash bombs are used for illuminating the terrain briefly during night photo reconnaissance missions. When the fuse operates, the bomb's body bursts open and a special compound inside ignites, producing a bright flash which automatically triggers the shutter of the aircraft's night aerial camera

Simulation bombs

Simulation bombs are used for replicating the outward appearance of a mid-air or ground explosion of a nuclear bomb. The body is filled with kerosene and housing demolition charges (TNT and a different explosive mixture) and a capsule filled with white phosphorus. When the fuse operates, the demolition charges break open the bomb's body and the capsule with phosphorus, whereupon the phosphorus ignites the kerosene. The result is a tremendous fireball followed immediately by a rapidly growing, billowing white mushroom cloud – all the tell-tale signs of a nuclear explosion.

The phosphorus is needed to colour the cloud white for added realism

Simulation bombs

	IAB-3000	IAB-500
Overall length	3,297 mm (10 ft $9\frac{13}{16}$ in)	3,365 mm (11 ft $0\frac{31}{64}$ in)
Body diameter	820 mm (2 ft $8\frac{9}{32}$ in)	580 mm (1 ft $10\frac{53}{64}$ in)
Stabiliser span	1,002 mm (3 ft $3\frac{29}{64}$ in)	726 mm (2 ft $4\frac{37}{64}$ in)
Weight, kg (lb)	2,367 (5,218)	470 (1,036)

Practice bombs

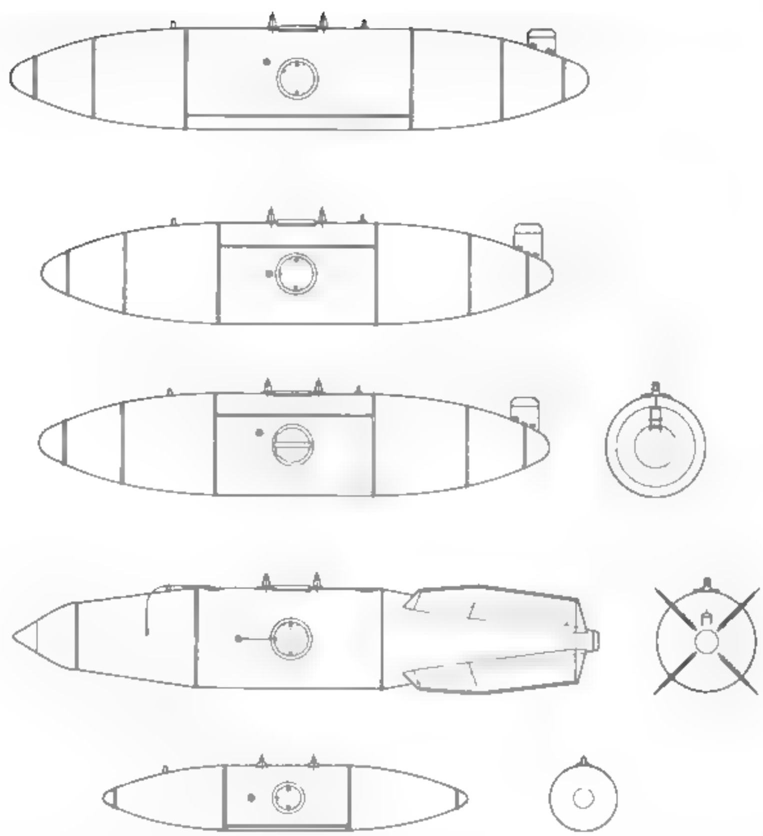
Practice bombs are used for training bomber crews in bomb delivery techniques, with provisions for simulating the deviation of retarded bombs due to strong winds. The fuse detonates a small charge at a preset altitude to eject a parachute-retarded flare; the latter descends, emitting light and smoke by which its position can be determined and the bombing accuracy judged. Meanwhile, the bomb's body loaded with ballast follows its own ballistic trajectory; the ballast is needed to provide the required weight and ensure the required CG position. Some practice bombs, such as the P-50Sh, are equipped with parabraking devices for simulating retarded bombs

The table below includes practice bombs pertaining to Type 1 (P-50-75, P-50T, P-50) and Type 2 (P-50Sh)

PROSAB-250 anti-aircraft bomb

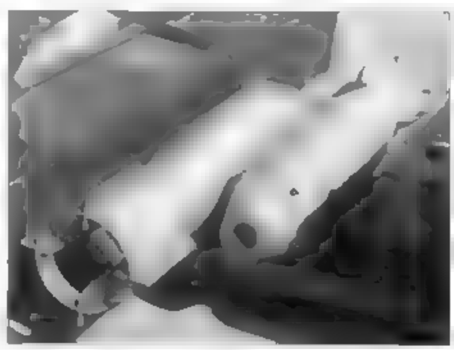
This unusual weapon (PROSAB = ***protivosamolyotnaya aviabomba*** – anti-aircraft bomb) included into the Soviet Air Force inventory in 1952 was developed for combating enemy bomber formations. Such bombs are dropped by fighters flying above the enemy formation to break it up, making it easier for other fighters to attack individual aircraft, and hopefully even destroy some of the bombers. In effect, the PROSAB-250 is a cluster bomb with fragmentation bomblets grouped around a central demolition charge inside a thin-walled outer casing The fuse detonates the demolition charge, bursting the outer casing and scattering the bomblets; the explosion also sets off the time fuses of the individual bomblets which then explode among the target aircraft a few seconds later

The PROSAB-250 was preceded by a smaller version, the PROSAB-100, which underwent tests on version of the MiG-15*bis* designated *izdeliye* SD-10; this aircraft commenced its state acceptance trials on 29th February 1952 (It has to be said that the idea was nothing new, having been pioneered on the Petlyakov VI-100 high-altitude fighter (the immediate precursor of the Pe-2 dive bomber) back in 1939; however, it was Germany that used the concept operationally against Allied night bombers during the Second World War)



Above, top to bottom: The ZB-500AS napalm tank; the ZB-500Sh (ZB-500ShN); the ZB-500GD whose contents ignite after coming into contact with water; the ZB-500 (ZB-500R/ZB-500M); and the ZB-250Sh (ZB-250ShM).

Below: Two P-50Sh practice bomb minus fuses and parabraking devices.



Practice bombs

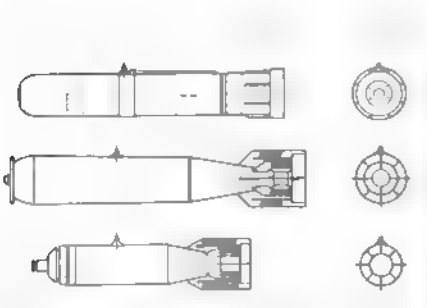
	P-50-75	P-50T	P-50	P-50Sh
Overall length	1,064 mm (3 ft $5\frac{57}{64}$ in)	1,112 mm (3 ft $7\frac{25}{32}$ in)	970 mm (3 ft $2\frac{3}{16}$ in)	1,097mm (3 ft $2\frac{3}{16}$ in)
Body diameter	203 mm (8 in)	203 mm (8 in)	205 mm ($8\frac{5}{64}$ in)	203 mm (8 in)
Stabiliser span	245 mm ($9\frac{41}{64}$ in)	245 mm ($9\frac{41}{64}$ in)	280 mm (11 in)	245 mm ($9\frac{41}{64}$ in)
Weight, kg (lb)	71 (156)	50 (110)	55 (121)	46 (101)

Type 1 anti-tank and armour-piercing bombs

	PTAB-2,5	PTAB-2,5KO	PTAB-1	PTAB-10-5	BrAB-500
Overall length	362 mm (1 ft 2¼ in)	282 mm (11⅛ in)	262 mm (10 5/16 in)	360 mm (1 ft 2 11/64 in)	2,388 mm (7 ft 8 in)
Body diameter	60 mm (2 23/64 in)	60 mm (2 23/64 in)	42 mm (1 21/32 in)	90 mm (3 35/64 in)	388 mm (1 ft 3 9/32 in)
Stabiliser span	90 mm (3 35/64 in)	60 mm (2 23/64 in)	74 mm (2 29/32 in)	120 mm (4 47/64 in)	400 mm (1 ft 3¾ in)
Weight, kg (lb)	2.23 (4.96)	1.7 (3.74)	0.98 (2.16)	4.77 (10.5)	531 (1,170)

Anti-submarine bombs

	PLAB-250-120	PLAB-50	UPLAB-50	PLABmk
Overall length	1,456 mm (4 ft 9 21/64 in)	992 mm (3 ft 3 in)	1,063 mm (3 ft 5 55/64 in)	391 mm (1 ft 3 25/64 in)
Body diameter	240 mm (9 7/16 in)	203 mm (8 in)	240 mm (9 7/16 in)	90 mm (3 35/64 in)
Stabiliser span	280 mm (11 in)	245 mm (9 41/64 in)	280 mm (11 in)	–
Weight, kg (lb)	117 (258)	65 (143)	42 (92.5)	7.5 (16.5)



Top to bottom: The S-3V anti-submarine bomb; the PLAB-250-120 anti-submarine bomb; the PLAB-50

The growing speeds and flight altitudes of modern bombers, together with changes in bomber tactics, soon rendered anti-aircraft bombs obsolete and the PROSAB-250 was phased out of production; yet, it could still be used as an ordinary cluster bomb against ground targets

Anti-tank/armour-piercing bombs

These two categories of bombs are designed for use against heavily armoured stationary targets and combat vehicles. The anti-tank bombs (PTAB) are shaped-charge bombs using the concentrated energy of the explosion to create a powerful directional stream of hot gases burning through the armoured skin of the target Such bombs are usually small-calibre bomblets dispensed from submunitions pods

Two models (the PTAB-2,5 and PTAB-10-5) are currently on the inventory; they are capable of penetrating armour up to 65 mm (2 9/16 in) and 200 mm (7⅞ in) thick respectively

In contrast, the armour-piercing bombs (BrAB) simply punch through the target's skin by virtue of their kinetic energy. Hence these bombs have specially reinforced, sharp-nosed bodies and fall at great speed, to increase the latter the AP bombs are made extra heavy (among other things, this is achieved by increasing the bomb's dimensions). AP bombs have only base fuses which detonate the charge when the bomb has penetrated the target's skin. The combat efficiency of such targets is low because the chances of a direct hit are small, especially if we are dealing with a pin-point target (such as a vehicle); besides, the aircraft can only carry a limited number of these bombs due to their bulk and weight. Only a single model, the BrAB-500, remains on the inventory as of this writing. Its stabiliser consists of four main fins welded together and connected by eight auxiliary fins or struts. When delivered at 500 km/h (310 mph) the BrAB 500 can puncture 70-mm (2¾ in) armour if dropped from 2,000 m (6,560 ft) and 85-mm (3 11/32 in) armour if dropped from 3,000 m (9,840 ft).

Anti-submarine bombs

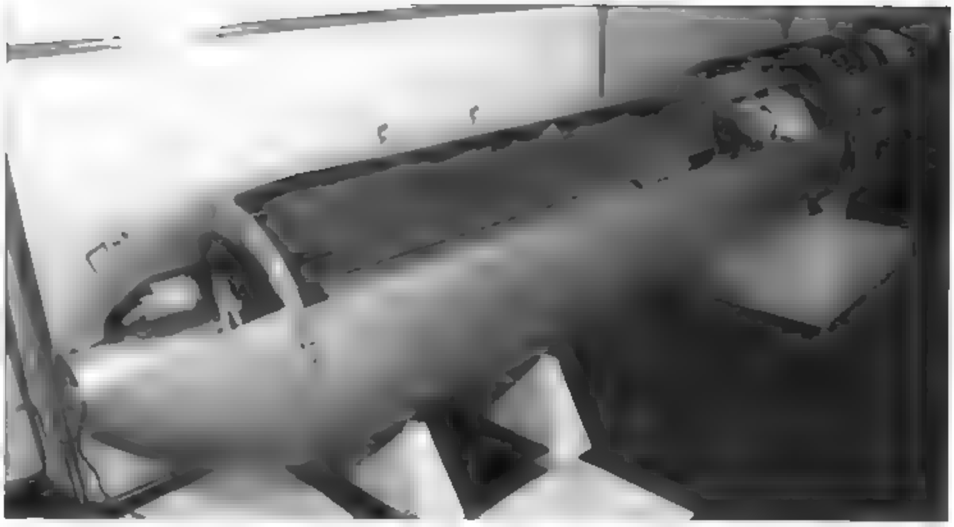
As the name suggests, these bombs are designed for anti-submarine warfare (ASW) and can be used against both surfaced and submerged submarines Only one model, the PLABmk bomblet sharing the dimensions of a 10-kg (22-lb) calibre bomb, is now on the inventory; it can be used against subs travelling or lying at depths of up to 300 m (980 ft). A direct hit must be achieved to score a 'kill', which is a pretty chancy affair if the submarine is submerged.

A curious aspect of the ASW bombs is that, like submarines with their 'double' hulls (an outer casing and a pressure hull), they have 'double' bodies fitting inside one another, the outer casing carrying the stabiliser serves as a 'barrel' from which the inner body containing the explosive charge is fired. The cylindrical stabiliser consists of a ring carried on four struts and six fins in the form of angle pieces welded to the inside of the ring, the fins are set at an angle to the bomb's axis to impart a stabilising rotation as the bomb moves through the water after splashdown. The 'warhead' (inner body) is ejected pyrotechnically on impact with the submarine's hull to make sure that both the outer casing and the pressure hull are ruptured by the explosion.

PLABmk bomblets are dropped from reusable submunitions pods carried by both fixed-wing aircraft and helicopters. It can be dropped at altitudes of 100-2,000 m (330-6,560 ft) and speeds of 250-700 km/h (155-434 mph)

Concrete-piercing bombs

Concrete-piercing bombs are designed for use against reinforced concrete structures, runways and aircraft hardstands, roads and such As distinct from ordinary 'iron' bombs, they feature solid-fuel rocket boosters



Left: Rear view of the BetAB-500ShP concrete-piercing bomb, showing the jettisonable parabrake section and the nozzle of the rocket motor increasing the bomb's impact speed.

Above and right: The ODAB-500PM fuel air bomb. The rear end houses a retarding device, while the nose accommodates the demolition charge and the igniter

increasing their impact speed Of the models listed in the table below, the BetAB 500 is a Type 1 bomb, the others pertain to Type 2

Psychological warfare bombs

Psy-war bombs are designed for disseminating various propaganda literature (leaflets and newspapers) over large areas of enemy-held territory In effect, they are cluster bombs, except for the non-explosive contents, and are invariably Type 1 bombs

Fuel/air bombs

Fuel/air bombs (ODAB – *ob"yomno-detoneeruyushchaya aviabomba*, lit. 'volume detonation air-dropped bomb') make up a new generation of bombs Their main effective factor is the powerful blast wave generated by a mid-air explosion; the blast wave is similar to the one created by a nuclear explosion but much less powerful Such bombs are filled with a high-calorie liquid fuel instead of the usual solid explosive When the fuse fires at a certain level above the ground, the bomb casing bursts, atomising the liquid contents as a huge aerosol cloud which is then ignited by a second detonator. One source describes the fuel/air bomb's principle of action as follows. the almost instantaneous combustion of the cloud of fuel mist burns up all the oxygen inside the resulting fireball, creating a vacuum (hence the description 'vacuum bomb' encountered sometimes), and the air rushing in from outside crushes everything!

Two models (the ODAB-500P and ODAB-500PM) are currently on the inventory. Both are 2,278 mm (7 ft 5 11/16 in) long, with a body diameter/stabiliser span of 500 mm (1 ft 7 11/16 in), and weigh 466 kg (1,027 lb)

Fuel/air bombs were used by the Soviet Air Force in the Afghan War, and reliability problems with these munitions persisted throughout the conflict. Their efficiency depended on many factors, including drop speed, altitude and hot-and-high conditions (ambient temperature and pressure); some sources claim that only 15-20% of these bombs detonated properly Hence fuel/air bombs were used sporadically, and then usually in combination with HE or incendiary bombs or rockets. Yet when they *did* work properly they were terrifying weapons – it was not for nothing they have been called 'the poor man's atomic bomb'. Buildings were flattened completely, and troops arriving on the scene later would find charred bodies and a few deaf and blind survivors

Psychological warfare bombs

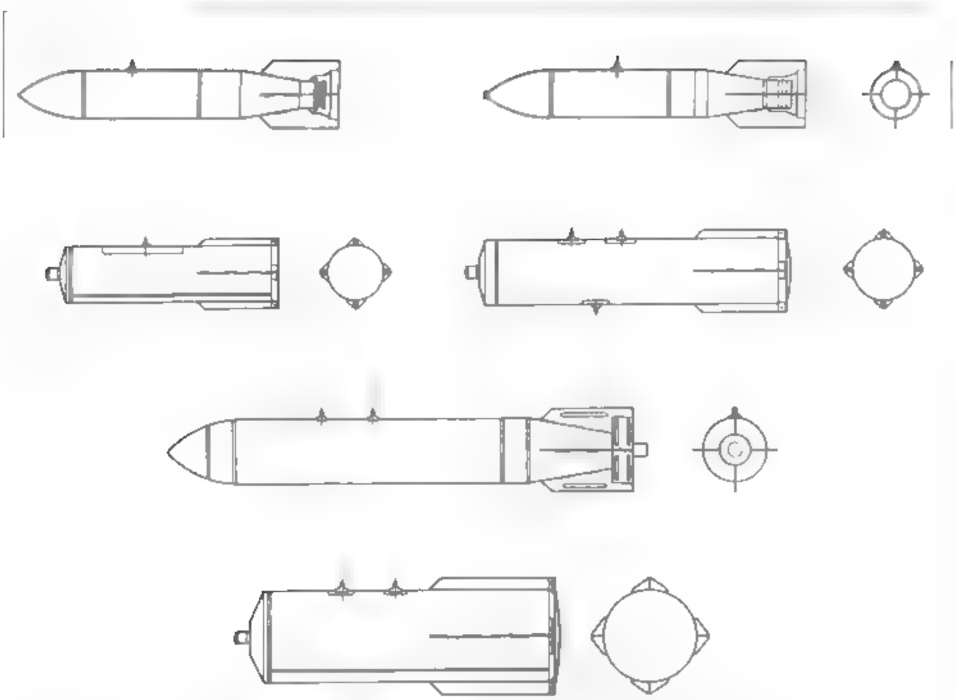
	AgitAB-500-300	AgitAB-250-85
Overall length	2,425 mm (7 ft 11 15/32 in)	1,483 mm (4 ft 10 25/64 in)
Body diameter	400 mm (1 ft 3¾ in)	325 mm (1 ft 0 51/64 in)
Stabiliser span	550 mm (1 ft 9 21/32 in)	410 mm (1 ft 4 9/64 in)
Weight kg (lb)	291-311 (641-685)	75-91 (165-200)

Concrete-piercing bombs

	BetAB-500	BetAB-500Sh	BetAB-500ShP
Overall length	2,197 mm (7 ft 2½ in)	2,792 mm (9 ft 1 59/64 in)	2,500 mm (8 ft 2 27/64 in)
Body diameter	350 mm (1 ft 1 25/32 in)	325 mm (1 ft 0 51/64 in)	325 mm (1 ft 0 51/64 in)
Stabiliser span	450 mm (1 ft 5 23/32 in)	601 mm (1 ft 11 21/32 in)	600 mm (1 ft 11⅝ in)
Weight kg (lb)	477 (1,051)	429 (945)	380 (840)

Flare bombs

Flare bombs are used for illuminating the terrain or target during night bombing raids. After being released the bomb floats gradually earthwards on a parachute as the contents of the body ignite, producing a bright light for an extended time. Flare bombs are Type 3 bombs



Day, night and coloured marker/signal flare bombs; smoke bombs

All of these munitions are used for marking waypoints on routes followed by aircraft groups, group assembly zones, landing zones (LZs) or drop zones (DZs) and the like. In their design the marker/signal flare bombs and smoke bombs are similar to ordinary flare bombs used for illumination purposes, differing in the brightness of their light (which is lower) and the chemical composition of the filling. The day marker/signal flare bombs create a conspicuous pillar of white, black or red smoke. Night and coloured marker/signal flare bombs give off a persistent red, green or yellow light. The stencils on the bomb's body include a letter indicating the colour of the light or smoke. K for ***krasnyy*** (red), Z for ***zelyonyy*** (green), Zh for ***zholtyy*** (yellow), B for ***belyy*** (white) or Ch for ***chornyy*** (black), for instance, NOSAB-100-80K, DOSAB-100-80B and so on.

Smoke bombs, on the other hand, are used for setting up smoke screens to conceal the positions of own troops from the enemy

Cluster bombs

Outwardly cluster bombs (RBK – ***razovaya bombovaya kasseta***, lit. 'disposable bomb cassette') look like ordinary Type 1 bombs. However, the body is a thin-walled casing concealing a cassette filled with small-calibre submunitions (pellet, fragmentation, anti-tank (shaped-charge), incendiary or other bomblets At a preset altitude the fuse fires and the resulting powder gases propel the cassette aft, causing the tailcone complete with the stabiliser to pop off and the submunitions to spill out into the slipstream. scattering over a large area

Guided bombs

Guided bombs can be divided into three groups: homing, remote-controlled and those with a combined control system. Remote control can be exercised via radio command link, using either an aircraft-mounted sight for keeping track of the target and the bomb or a closed-circuit television system transmitting a 'bomb's eye view' to the cockpit

Remote-controlled bombs with a simple radio command (line-of-sight) control system have the warhead located foremost

Flare bombs

	SAB-100-75	SAB-100MP	SAB-250-200	SAB-250T	SAB-500-350
Overall length	1,050 mm (3 ft 5 11/32 in)	1,065 mm (3 ft 5 59/64 in)	1,621 mm (5 ft 3 53/64 in)	2,340 mm (7 ft 8 1/8 in)	1,500 mm (4 ft 11 1/16 in)
Body diameter	280 mm (11 in)	280 mm (11 in)	325 mm (1 ft 0 51/64 in)	325 mm (1 ft 0 51/64 in)	450 mm (1 ft 5 23/32 in)
Stabiliser span	–	345 mm (1 ft 1 37/64 in)	410 mm (1 ft 4 9/64 in)	410 mm (1 ft 1 37/64 in)	570 mm (1 ft 10 7/16 in)
Weight kg (lb)	86 (189)	104 (229)	201 (443)	219 (482)	363 (800)

Marker/signal flare bombs and smoke bombs

	NOSAB-100T DOSAB-100T	NOSAB-100-70 NOSAB-100-80 DOSAB-100-80 DOSAB-100-70	TsOSAB-10	DAB-100-90FM	DAB-100-80
Overall length	1,560 mm (5 ft 1 27/64 in)	1,065 mm (3 ft 5 59/64 in)	873 mm (2 ft 10 3/8 in)	1,060 mm (3 ft 5 47/64 in)	1,057 mm (3 ft 5 39/64 in)
Body diameter	240 mm (9 7/16 in)	280 mm (11 in)	107 mm (4 7/32 in)	280 mm (11 in)	280 mm (11 in)
Stabiliser span	330 mm (1 ft 1 in)	310 mm (1 ft 0 13/64 in)	150 mm (5 29/32 in)	280 mm (11 in)	308 mm (1 ft 0 1/8 in)
Weight, kg (lb)	115-119 (253-262)	68-87 (150-191)	12 (26.4)	92 (202)	73 (161)

Cluster bombs

	RBK-500ShOAB-0,5M RBK-500AO-2,5RT RBK-500PTAB-1 RBK-500ZAB-2,5SM	RBK-500-375AO-10 RBK-500-225PTAB-2,5 RBK-500-255PTAB-10-5	RBK-500ShOAB-0,5	RBK-250-275AO-1SCh RBK-250PTAB-2,5M
Overall length	1,925 mm (6 ft 3 25/32 in)	1,500 mm (4 ft 11 3/64 in)	1,500 mm (4 ft 11 3/64 in)	2,151 mm (7 ft 0 11/16 in)
Body diameter	450 mm (1 ft 5 23/32 in)	450 mm (1 ft 5 23/32 in)	450 mm (1 ft 5 23/32 in)	325 mm (1 ft 0 51/64 in)
Stabiliser span	568 mm (1 ft 10 23/64 in)	570 mm (1 ft 10 7/16 in)	570 mm (1 ft 10 7/16 in)	410 mm (1 ft 1 9/64 in)
Weight, kg (lb)*	391 (862) 338 (745) 435 (959) 435 (959)	379 (835) 225 (496) 253 (557)	334 (736)	280 (617) 248 (546)

* In order of models listed

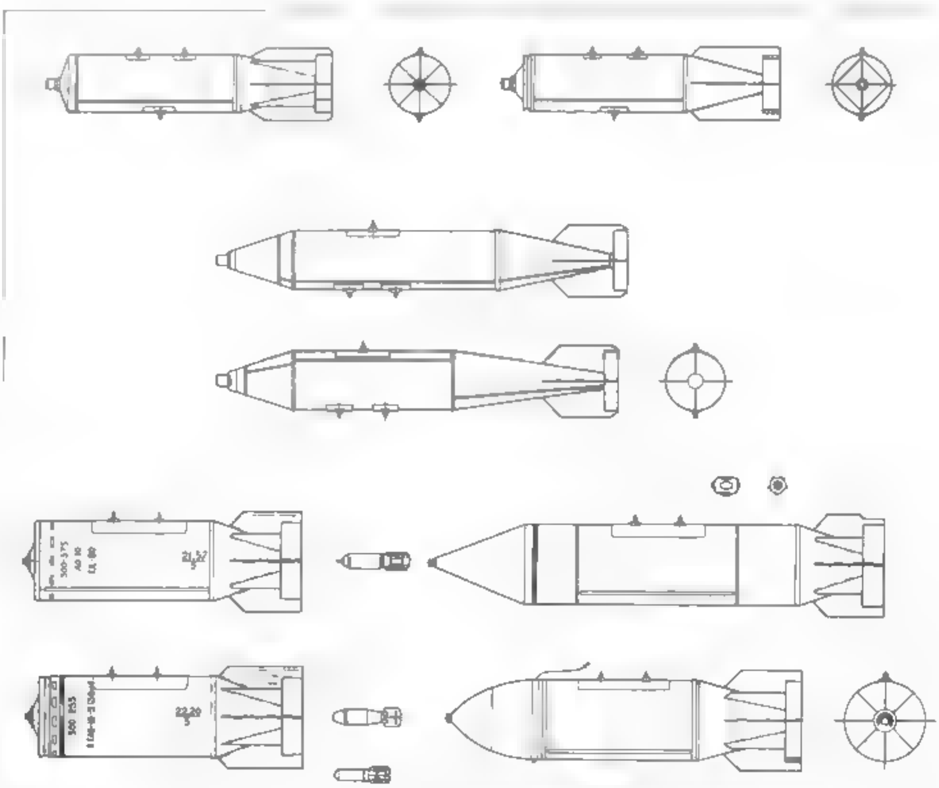
Cluster bombs (continued)

	RBK-250-170MA-3	RBK-250ZAB-2,5M	RBK-250AO-1	RBS-100AO-25-33†
Overall length	1,500 mm (4 ft 11 3/64 in)	1,494 mm (4 ft 10 53/64 in)	1,499 mm (4 ft 11 1/64 in)	1,065 mm (3 ft 5 59/64 in)
Body diameter	325 mm (1 ft 0 51/64 in)	325 mm (1 ft 0 51/64 in)	325 mm (1 ft 0 51/64 in)	122 mm (4 51/64 in)
Stabiliser span	410 mm (1 ft 1 9/64 in)	410 mm (1 ft 1 9/64 in)	407 mm (1 ft 4 1/64 in)	280 mm (11 in)
Weight, kg (lb)	171 (376)	174 (383)	196 (432)	119 (262)

† RBS = *razovaya bombovaya svyazka*, lit. 'disposable bomb cluster'

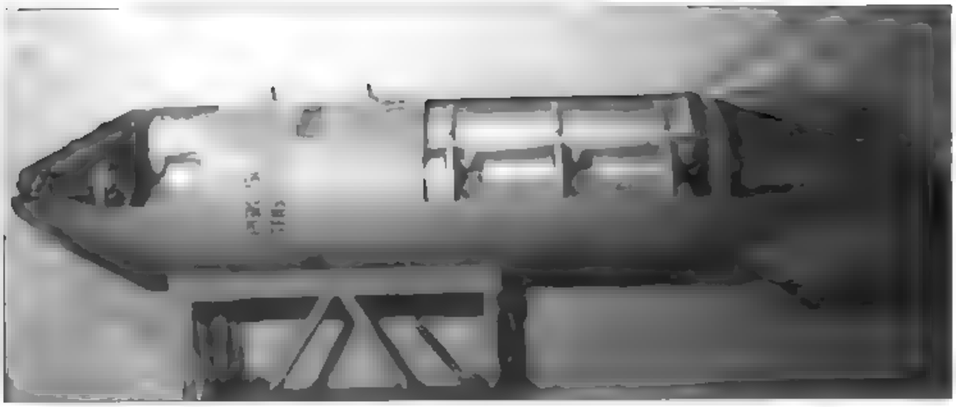
followed by the control system module with rudders. A homing bomb or a TV-guided bomb has the homing system's target co-ordinator (or, respectively, the TV seeker head feeding the image to the aircraft via real-time data link) installed ahead of the explosive charge.

The first guided bombs were developed by Nazi Germany immediately prior to the outbreak of the Second World War (in the late 1930s). Their first operational use dates back to 1942; such bombs were used by the Luftwaffe against Allied shipping in the Baltic Sea and later in the Mediterranean. The



This page, left to right, top top to bottom: The RBK-250-170MA-3 and RBK-250 ZAB-2,5M cluster bombs; the RBK-250PTAB-2,5M and RBK-250-275 AO-1SCh; the RBK-500-375AO-10 with an AO-10 bomblet; the RBK-500AO-2,5RT with an AO-2,5RT bomblet, the RBK-500-255 PTAB-10-5 with PTAB-10-5 and PTAB-2,5 bomblets; and the RBK-500ShOAB-0,5M (or RBK-500ZAB-2,5SM).

Opposite page, left to right, top top to bottom. The DOSAB-100T and NOSAB-100T day and night signal/marker flare bombs; the SAB-100, SAB-250, SAB-250T and SAB-500 flare bombs.



Left: A cutaway RBK-500SPBE-D cluster bomb, showing the PTAB-SPD shaped-charge bomblets inside

most successful operation involving the use of PC-1400 Fritz X guided bombs took place in September 1943 when German aircraft attacked the warships of Germany's former ally; in this raid the Italian Navy's latest battleship, the *Roma*, was sunk and a sister ship was seriously damaged. Later the Luftwaffe succeeded in sinking or damaging other Allied battleships, cruisers and destroyers, making use of Fritz X bombs. In 1945 these bombs were used in land warfare to demolish the bridges by which the advancing Soviet troops were trying to cross the Oder

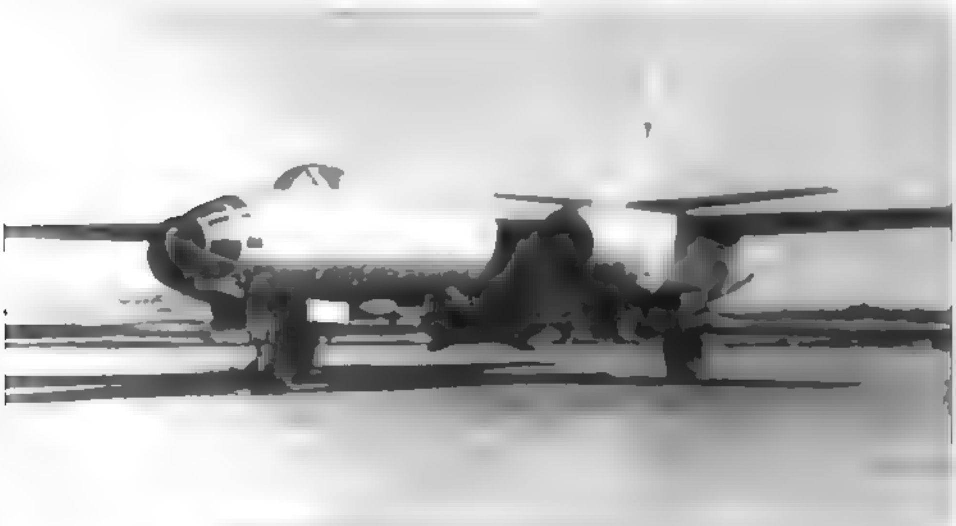
The USA also used several models of guided bombs in the Second World War Later, such weapons (known in US Army slang as 'hobos', an acronym for 'HOming BOmb') were widely used, and with considerable success, against North Korean targets in the Korean War of 1950-53. It was the successful use of homing bombs in Korea that led the Soviet Union to start work in this field as well

For starters, captured German guided bombs were tested The results were disappointing because the German radio command guidance system was not effective enough by the standards of the 1950s, and copying these bombs was deemed inexpedient. In October 1951 the Ministry of Agricultural Machinery's KB-2 design bureau headed by Aleksandr Davidovich Nadiradze began development of two guided bombs the 5,100-kg (11,240-lb) UB-5 Condor (aka UB-5000F; UB = *oopravlyayemaya **bomba*** – guided bomb) with a 4,200-kg (9,260-lb) HE warhead and the 2,240-kg (4,940-lb) UB-2F ***Chaika*** (Seagull, aka UB-2000F) with a 1,795-kg (3,960-lb) HE warhead Before the war, Nadiradze had gained some recognition for his work on air cushion landing gear systems for aircraft; it was in the post-war years that he became head of a rocket weapons design bureau

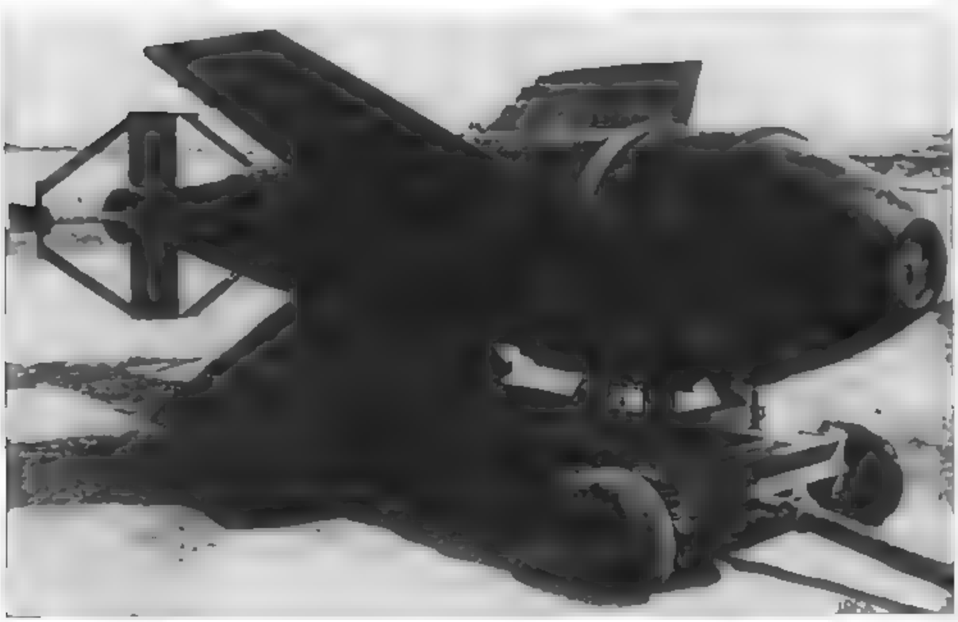
In December 1951 Nadiradze's KB-2 merged with plant No 67, changing its name to GSNII-642 (*Gosoo**darstvennyy** soy**oozny**y naoochno-**issledovatel'**skiy instit**oot*** – State Union Research Institute No 642; the 'Union' bit indicated that the establishment had national importance). In November 1957 GSNII-642 was amalgamated with Vladimir N Chelomey's OKB-52, becoming a branch office of this OKB tasked with cruise missile guidance system development (see Chapter 2) By the early 1980s guided bomb development in this establishment had ground to a halt; Nadiradze quit and went on to work for NII-1, developing ballistic missiles with solid-fuel rocket motors

UB-2000F (UB-2F Chaika, 4A-22) guided bomb

A development batch of UB-2000F bombs was manufactured as early as 1953, allowing trials to begin; specially modified Tu-4 heavy bombers and Il'yushin IL-28 twinjet tactical bombers were used as the delivery vehicles It transpired that that two or three 'smart bombs' were enough to destroy a target measuring 30 x 70 m (100 x 230 ft) that



Above left: An IL-28-131 with a UB-2F Chaika guided bomb suspended under the fuselage Note the characteristic angular bulge under the nose associated with the bomb guidance system.



Left: The KRAB was another early Soviet guided bomb. Note the two closely set 'eyes' of the IR homing system and the shape of the tail surfaces.

would have required the expenditure of 168 FAB-1500 'dumb bombs'. Hence in 1955 the UB-2000F entered production and was brought into the inventory as the UB-2F Chaika or *izdeliye* 4A-22. About thirty IL-28-131 bombers and a small number of Tu-16 Chaika bombers specially equipped to carry these precision-guided munitions were built in 1956, the Il-28-131 carried a single bomb externally under the fuselage, while the Tu-16 Chaika carried two such bombs on underwing pylons.

Outwardly the UB-2000F bore a certain resemblance to the Fritz X, but the similarity was limited to the squashed-X wing arrangement, the twin tails and the use of spoilers. Apart from the need to provide adequate ground clearance, the wing shape was determined by the similar control authority requirements in the vertical and horizontal planes. The Soviet bomb's wings were of delta planform with sharply swept leading edges (due to the high speed of the aircraft which were to carry it) and the casing had a constant diameter; in contrast, the German bomb had unswept trapezoidal wings and a bulged warhead

Another difference was that the wings were made of aluminium alloy and attached to the casing by bolts; the Fritz X had steel wings welded to the casing. The wing planes were set at 28° (dihedral for the upper pair and anhedral for the lower one) and wing sweep was 45° Both ends of the horizontal tail carried red tracers for visually tracking the bomb's flight

Like its German forebear, the UB-2F was controlled by means of spoilers and the tail surfaces. The spoilers were narrow strips on the wing trailing edges oscillating with a frequency of 5 Hz to protrude into the slipstream above and below the wing surface by turns. To alter the bomb's trajectory in a given direction the spoilers needed to deflect to one side more frequently than to the opposite side, therefore they were provided with rapid-action electromagnetic actuators, which appeared to be a simpler solution than traditional hydraulic or mechanical drives

The steel casing consisted of a warhead and a guidance and stabilisation system compartment aft of it. The warhead was provided with two AV-139 impact fuses The rear compartment housed a receiver capable of operating in three wavebands and a signal amplifier/decoder – both part of the bomb's KRU-UB radio command guidance system (*komanhdnoye rahdio'upravleniye ooprav-lyayemoy bomboy*) – and the BU-2 control module (*blok oopravleniya*); the latter included an AP-59 autopilot and a DC battery

The aircraft's on-board part of the KRU-UB system transmitted the guidance signals in continuous mode. The system had three transmitters operating in different wavebands simultaneously to frustrate jamming, however, only one of the 600 possible frequencies was actually used at a time for bomb guidance, the other two frequencies being intended for deceiving the enemy. The transmitters were controlled from a control panel on the special OPB-2UP periscopic synchronised bombsight (*opticheskiy pri-tsel bombardirovochnyy*). The OPB-2UP was used for dropping free-fall and guided bombs in level flight. It automatically signalled proximity to the moment of bomb release and dropped the bomb at the right time. Guidance was effected through the sight by a juxtaposition of the bomb's image with a moving indicator registering the angles of divergence derived from calculating the bomb's trajectory and generated by a special computer

The UB-2F's release process was similar to that of ordinary 'dumb bombs', except that at least three minutes' allowance had to be made for spinning up and tuning the bomb's gyros and activating the data link equipment. Pitch and yaw control of the bomb was effected by the bombardier by means of the 4A-N1 data link system. Roll control and stabilisation was the responsibility of the autopilot

The UB-2F used triangulation as the principal guidance method, the bombardier keeping the bomb on a straight line between the aircraft and the target. The bomb's flight path could be rather different from the parabolic trajectory followed by free-fall bombs. If no commands were forthcoming the UB-2F glided in a shallow dive, staying below the line connecting the aircraft and the target; therefore the bomb needed to be guided onto this line by programmed commands before triangulation guidance could begin. As the bomb's speed was lower than that of the aircraft, triangulation guidance could only be performed after the aircraft had passed over the target, the bomb performing a programmed turn to dive onto the target. For example, when dropped at 7,000 m (22,965 ft), the UB-2F was released at a distance of 2.6 km (1.6 miles) from the target and travelled more than 4 km (2.5 miles) in the same direction, making a U-turn for the final dive when the bomber was already 5 km (3.1 miles) beyond the target.

The Chaika's operational use technique had several inherent flaws. For one thing, the system could only be used in good visibility conditions when both the bomb and the target could be observed through the sight; for another, the bomber needed to pass in a straight line directly above the target, which made it vulnerable to enemy air defences. The bomb could be released at 5,000-15,000 m (16,400-49,210 ft) and 400 900 km/h (248-559 mph).

The UB-2F (UB-2000F) had a high-explosive warhead (F = *foogahsnaya* – high-explosive), but the UB 2000B armour-piercing version (*broneboynaya*) was also envisaged In 1955 the Nadiradze team developed the passive infra-red homing Chaika-2 and the passive radar homing Chaika-3, although only the HE version was actually tested and accepted for operational use in December 1955

The Chaika-2 differed mainly in having a bulky IR seeker head designated 0-1-54; its sensitivity was rather low, rendering it suitable only for use against large targets with a high heat signature, such as metal foundries, thermoelectric power stations and large ships. After release the bomb was to glide in autonomous mode for a while until the IR seeker head achieve target lock-on; there was no radio command guidance. The Chaika-2 was to be 50 kg (110 lb) heavier and 220 mm (8²⁄₃₂ in) longer than the baseline version. A similar IR-homing bomb called Krab (Crab; the name was probably an acronym for *korrekteeruyemaya avi-abomba*) was under development at an OKB headed by A. V. Svechannov since 1948.

The Chaika-3 was intended for use against enemy radar and ECM sites. It was to feature a PRG-10V passive radar seeker head

UB-5000F Condor guided bomb

Designed for use against large surface ships, the UB-5000F Condor was basically a scaled-up version of the UB-2F. Its development lagged behind that of the Chaika, as GSNII-642 wanted to make sure that any development problems encountered with the smaller bomb would be designed out of the larger one. The number of spoilers was doubled as compared to the Chaika and the tail section of the body had a different shape

Two versions were developed, one using line-of-sight radio command guidance (like the Chaika) and the other TV guidance. The latter version underwent trials on a modified Tu-4 as early as September 1954. Early tests gave disappointing results, the accuracy proving significantly poorer than the UB-2F's because the heavier Condor reached speeds in the order of Mach 1.1 and was less stable in flight. To improve stability and control the wing dihedral/anhedral was increased to 31° and special endplates were fitted to all four wings, the endplates were vertical, not at right angles to the wings

The problems were eventually overcome and satisfactory results obtained through the speed range. In August 1955 experimental Condor bombs were again tested from the Tu-4, followed by tests on the

First-generation guided bombs

	UB-2000F	UB-5000F	UBV-5
Overall length	4,730 mm (15 ft $6\frac{7}{32}$ in)	6,846 mm (22 ft $5\frac{17}{32}$ in)	6,200 mm (20 ft $4\frac{3}{32}$ in)
Body diameter	600 mm (1 ft $11\frac{5}{8}$ in)	850 mm (2 ft $9\frac{15}{32}$ in)	850 mm (2 ft $9\frac{15}{32}$ in)
Wing span	1,560 mm (5 ft $1\frac{27}{64}$ in)	1,810 mm (5 ft $11\frac{1}{4}$ in)	1,045 mm (3 ft $5\frac{9}{64}$ in)
Weight kg (lb)	2 240 (4,940)	5 100 (11 240)	5 150 (11 350)

Tu-16 'Condor' development aircraft in March 1956. Yet, although successful, the system was not accepted for operational service, as the The large bomb carried externally increased drag to the detriment of both speed and range. Work was already under way on the UBV-5 guided bomb

UBV-5 guided bomb

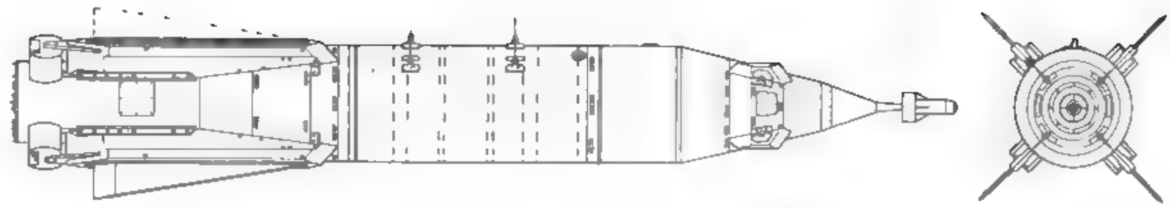
Development of the 5,150-kg (11,350-lb) UBV-5 guided bomb fitted with a 4,200-kg (9 260-lb) HE or armour-piercing warhead began in July 1956. Since supersonic bombers were strongly on the agenda, internal carriage was a prime requirement (the alternative semi-recessed option was rejected by the Soviet Air Force)

Due to the rigid restrictions on the bomb's dimensions and the different release conditions the UBV-5 looked rather different from the other first-generation Soviet guided bombs, looking like a missile with short-span cruciform wings and rudders set at 45° to the horizontal plane. Pitch and directional control was exercised by the all-movable aft-mounted rudders, while the wings featured inset ailerons for roll control and stabilisation.

Left: The KAB-500T TV-guided bomb (foreground) and the KAB-1500L-F laser-guided bomb at one of the Moscow airshows.

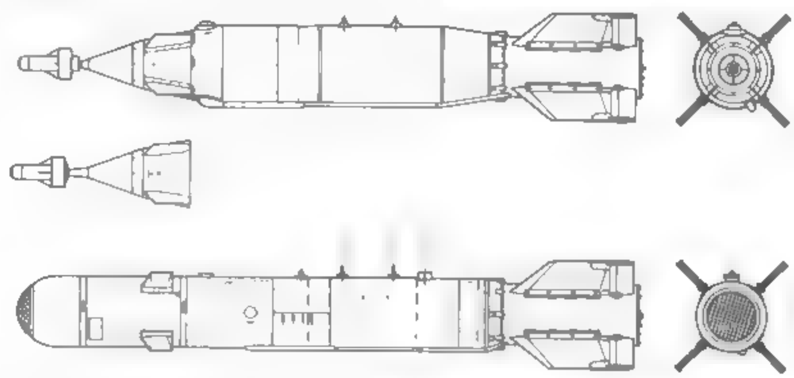
Below left: A photo of the KAB-500T from an NPO Bazal't ad. The bomb has aft-mounted rudders.

Below right: The larger KAB-1500L-F has control surfaces fore and aft and a stabilising ring on the gimballed seeker head.



Above: The KAB-1500L-F laser-guided bomb; the KAB-1500L-PR is identical. The fins are folded while the bomb is on the pylon, as shown for the upper fins.

Right. The KAB-500L (with two versions of the seeker head) and the TV-guided KAB-500KR



The UBV-5 was envisaged in both radio-controlled and IR-homing versions. Development of the UBV-5 was abandoned for several reasons – mainly because the emphasis shifted to air-launched cruise missiles able to strike at the target without taking the aircraft within range of the enemy air defences. The same fate befell the 7,500-kg (16,530-lb) UPB rocket-powered guided bomb which was to be released at a range of 300-350 km (186-217 miles) from its target

Second-generation guided bombs

A second generation of guided bombs was brought out in the 1980s. Designated KAB (*korrekteeruyemaya aviabomba*), these are precision-guided munitions intended for destroying small and highly resistant targets, such as hardened aircraft shelters, bunkers and other reinforced concrete structures, bridges and so on. Unlike ordinary free-fall bombs, they feature a guidance system and a power source for the latter Normally guided bombs have aft-mounted rudders and a forward-mounted seeker head.

Two types of guidance systems are the most common among such weapons. Laser-guided bombs feature a semi-active laser seeker head of the kind found on laser-guided air-to-surface missiles. This requires the target to be illuminated by an aircraft-mounted or ground-based laser designator, picking up the reflected beam and generating guidance signals for the rudder actuators. TV-guided bombs are aimed by the pilot, using a 'bomb's eye view' picture transmitted to a TV screen in the cockpit; this requires the pilot (or weapons systems operator) to track the relative positions of the target and the bomb, controlling the latter's flight by means of a mini-joystick

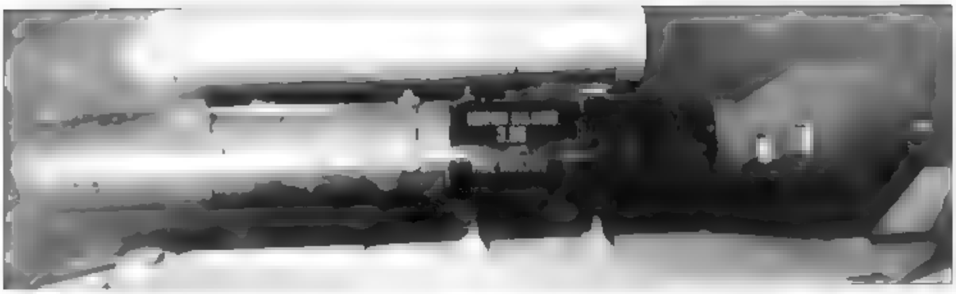
The KAB-500LK is a shaped-charge version of the KAB-500L (hence the K for *kumulyativnaya*)

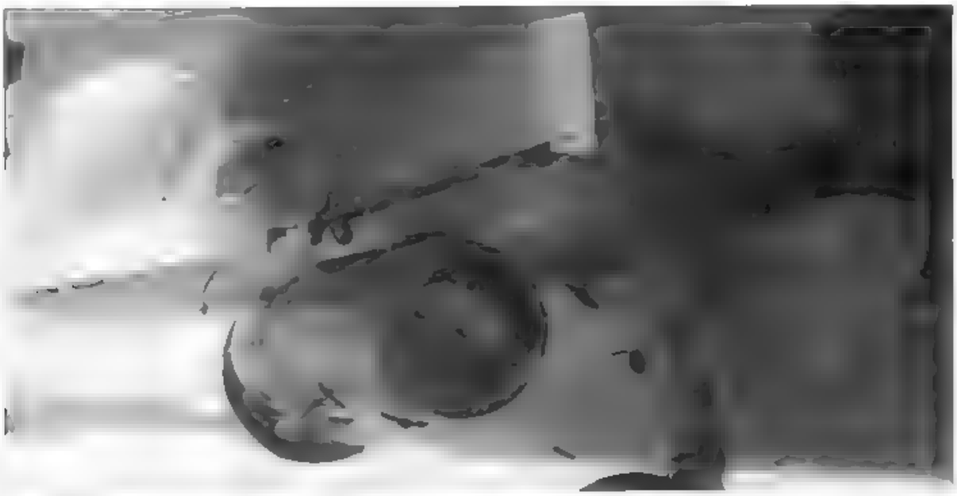
TV-guided bombs are capable of homing onto parked aircraft and the like at 15-17 km (9 310.5 miles) range. As distinct from American TV-guided or IR-homing 'smart bombs', their Russian counterparts are capable of finding and destroying low-visibility (for example, camouflaged) targets whose co-ordinates are known and can be downloaded to the bomb

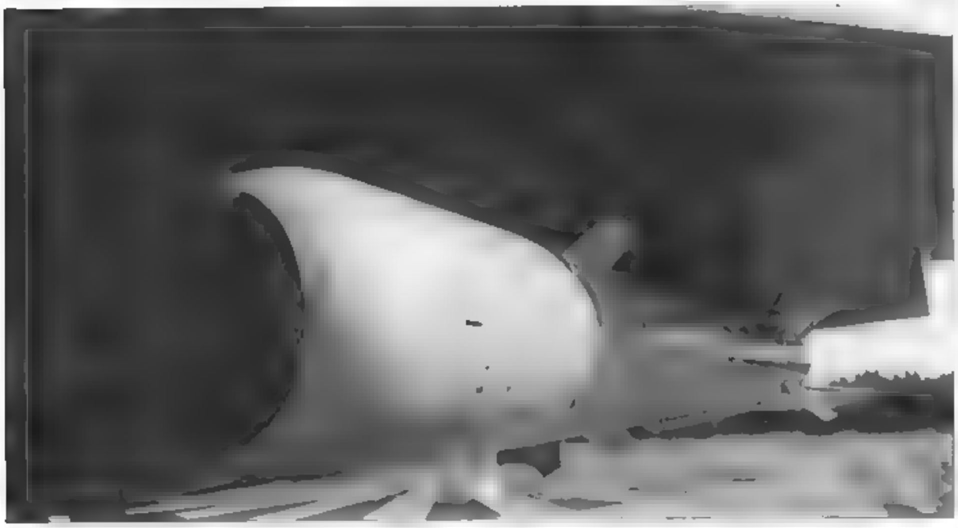
The KAB-500KR has an armour-piercing warhead that can penetrate obstacles up to 1 5 m (4 ft 11 in) thick, even if they are 10 m (33 ft) underground. The KAB-500D (*[ob"yomno-] detoneeruyushchaya)* is a fuel/air bomb The KAB-1500 is characterised by folding triangular fins which deploy when the bomb is dropped. The above models can be carried both by the latest Russian combat aircraft (such as the Su-34) and by older models (for instance, the MiG-27K) if they are fitted with special guidance system pods

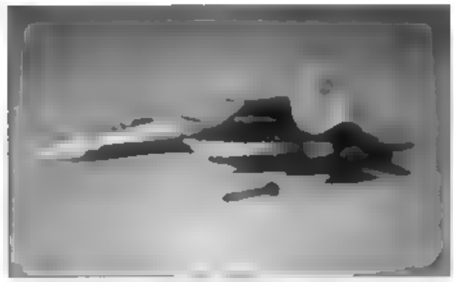
Second-generation guided bombs

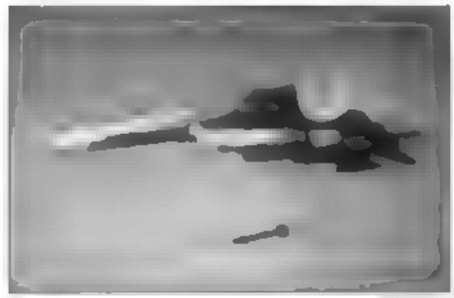
	KAB-500L	KAB-500KR	KAB-1500L-F	KAB-1500L-PR
Guidance system	Laser	TV	Laser	Laser
Overall length	3,040 mm (9 ft 11 11/16 in)	3,050 mm (10 ft 0 1/16 in)	4,600 mm (15 ft 11 in)	4,600 mm (15 ft 11 in)
Body diameter	400 mm (1 ft 3 3/4 in)	350 mm (1 ft 1 25/32 in)	580 mm (1 ft 10 27/32 in)	580 mm (1 ft 10 27/32 in)
Wing span	750 mm (2 ft 5 17/32 in)	850 mm (2 ft 9 15/32 in)	850-1,300 mm (2 ft 9 15/32 in - 4 ft 3 3/16 in)	850-1,300 mm (2 ft 9 15/32 in – 4 ft 3 3/16 in)
Weight, kg (lb)	534 (1,177)	560 (1,234)	1,560 (3,440)	1,500 (3,306)











Above: Sequence of stills from a video showing the as-yet unpainted Su-30KN upgraded multi-role combat aircraft ('302 Blue') dropping a KAB-500T bomb.

Top left: The KAB-500T on display at one of the 'open doors days' at Kubinka AB.

Centre left: A fixed acquisition round version of the KAB-500T exists. It is basically the bomb's TV seeker head (complete with the fixed canard foreplanes) with the rear end closed by an ogival fairing.

Left: The KAB series of bombs can be carried by Russia's fourth-generation combat aircraft, such as this Su-27SKM, and third-generation jets, providing they are retrofitted with appropriate guidance equipment.

This picture shows a KAB-500T bomb under the wing of a MiG-29M prototype. Lacking a built-in marked target seeker, the MiG-29M needs to be fitted with a laser designator pod.

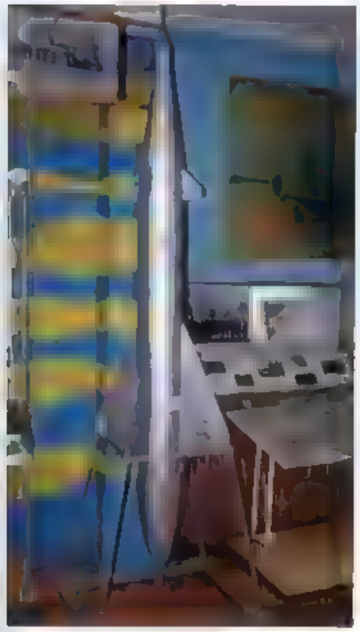
SOVIET / RUSSIAN AIRCRAFT WEAPONS IN COLOUR

Left: An inert RS-2-US training round in a Polish museum; note the appropriate inscription *Szkolny* ('for training') and the unusual sky blue colour.

Below left: Most examples of the type, like this one at the Central Russian Air Force Museum at Monino near Moscow, were painted silver.

Below: The aircraft armed with the RS-2-US missile included the experimental SM-12PM interceptor, one of the stepping stones from the MiG-19 to the MiG-21.

Bottom: An excellent shot of '18 Blue', an operational MiG-19PM carrying a full set of four RS-2-USs.



Left: This preserved MiG-21PFM fighter carries an interesting combination of an RS-2-US beam-riding missile on an APU-7 launch rail inboard and an R-3T heat-seeking AAM on a BD3-60-21U launch rail.

Below: The T47-5 (the fifth prototype of the Su-11 interceptor) with two orange-painted inert K-8MT missiles. Note the all-metal air intake centrebody instead of the planned dielectric radome and the four 'kill' stars marking successful test launches of IR-homing missiles during the trials.

Bottom: '33 Blue', the third prototype Su-15 *sans suffixe* (the T58D-3), at an early stage of the trials with two dummy R-98T missiles. Note the undernose antenna pod which was later removed.

Opposite page, above and below: The first pre-production Novosibirsk-built Su-15 ('34 Red', c/n 0015301) seen during trials. The R-98T missiles in this case are obviously inert but real ones (instrumented test rounds), as the IR seeker heads are clearly visible. These photos illustrate some of the *Flagon-A*'s design features, including the pure delta wings and the area-ruled fuselage near the air intakes.

Left: The SM-9/3T weapons testbed that served for testing the R-3T heat-seeking missile. The missile pylons were attached to the drop tank hardpoints.

Below: Appropriately coded '82 Red', the Ye-8/2 was the second prototype of the Ye-8 tactical fighter that would have been designated MiG-23, had it achieved production status here the aircraft carries a pair of dummy R-3T missiles.

Bottom: This MiG-21bis carries a full complement of weapons – two R-3Ts inboard and four inert R-60s on APU-60-2 launchers outboard.

Right: A pair of MiG-23Ms in air superiority grey colours armed with four R-13Ts each fly a patrol mission with the wings at 72° maximum sweep.

Below right: This Polish Navy MiG-21PFM painted to mark the 40th anniversary of its unit carries four R-3Ts on paired launch rails.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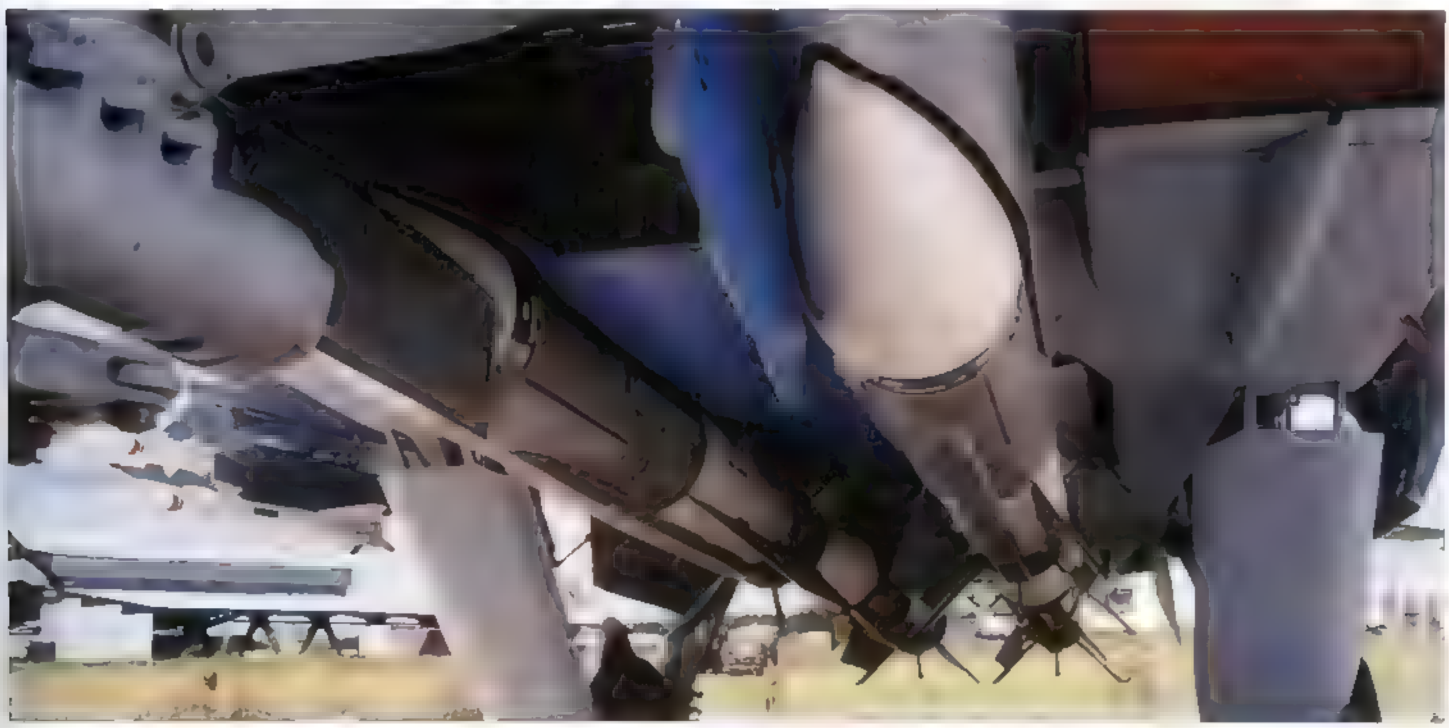
Above: Wearing blue trim typical of the Mikoyan OKB's development aircraft, the sixth MiG-25P prototype (the Ye-155P-6) shows off the quartet of R-40R radar-homing missiles.

Right: An R-40TD heat-seeking AAM on the port inboard wing pylon of MiG-31 '374 White', a Mikoyan OKB demonstrator.

Below: A look under the belly of the same aircraft shows its main weapons – the four R-33 long-range AAMs. The forward pair is semi-recessed.

Left: Sporting the three-tone tactical camouflage applied after refurbishment, Polish Air Force MiG-23MF '457 Red' carries a pair of medium-range R-23 missiles under the wing gloves (the starboard one is an R-23R) and four R-60s under the fuselage for close encounters.

Below left: The Mikoyan Ye-152P heavy interceptor with K-80 missiles on wingtip launch rails. This installation proved unsatisfactory and was replaced by underwing pylons.



Left: A fine perspective of MiG-31B '903 White' (c/n N38401208786), another Mikoyan demonstrator, showing the four R-33s under the fuselage and two black-striped inert R-40TDs under the wings.

Below left: MiG-31B '77 Blue' on display at Savasleyka AB with its weapons arrayed in front – two R-40TDs, four R-33s, four R-60Ms and 30-mm ammunition for the built-in GSh-30-6 cannon.

Right: This perspective of the final MiG-31M prototype ('057 Blue') at Zhukovskiy shows the six R-37 ultra-long-range AAMs located three-abreast under the fuselage. Note the fairings ahead of the missiles' noses and the different colour of the radomes.

Below: One of the four MiG-29SE demonstrators painted in this improbable camouflage scheme shows off its ability to carry two R-27R medium-range AAMs and four R-73 'dogfight AAMs'. An R-27TE (left) and an R-27RE (right) with fatter long-burn motors are displayed in front of the machine, along with an R-77 (far left), another R-73 (far right) and napalm tanks.

Left: An inert orange/white R-73 under the port air intake of the Irkut factory's MiG-27M demonstrator ('01 Blue'). It represents the variety with pitch/yaw vanes sometimes called R-73RMD.

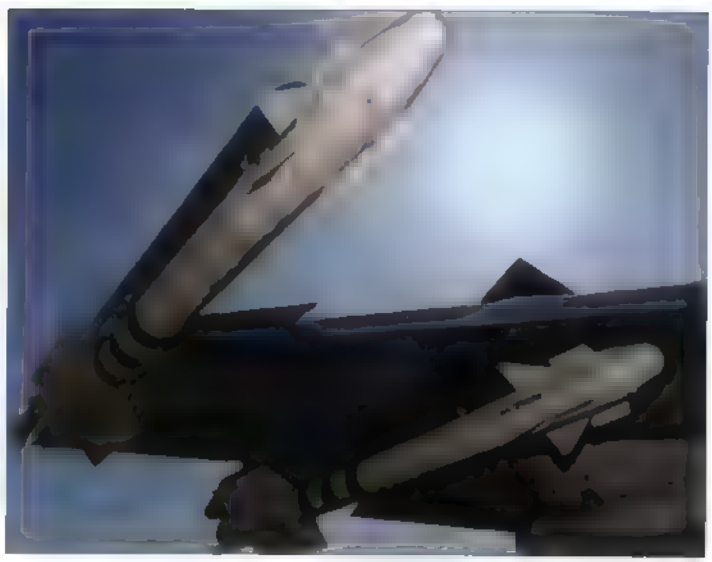
Left: An R-73 without pitch/yaw vanes (the blanking plates where they should be are just visible from under the protective cap on the seeker head)

Below and bottom: Cutaway examples of the R-73 used as teaching aids.

Right: Two R-73s on a ground handling dolly built for four such missiles – the maximum quantity normally carried by a single aircraft

Below: An R-73 under the port outer pylon of MiG-29 '331 Blue' (c/n 2960525975)

Foot of page: Dummy R-73s on the wingtip launch rails of a Su-27 operated by the *Rooskiye Vityazi* (Russian Knights) display team (left) and the Su-27SKM multi-role fighter prototype (right)



Top: '10 Blue', the famous MiG-29 which made the type's show debut at Farnborough International '89 and crashed at Le Bourget on 8th June 1989), with inert R-27Rs inboard and R-60s outboard.

Above. MiG-29SE '999 White' carrying inert R-27Rs. The R-73s on the outer pylons are inert; the ones on the centre pylons are dummies.

Left. This model showing an early project configuration of the MiG-29 features two AAMs looking like AIM-7 Sparrows and carried in similar fashion to the McDonnell Douglas F-15 Eagle.

Above right: Su-27 '08 Red', the famous 'Lipetsk Shark', loaded with R-27Rs and R-73.

Right: Su-27SKM '305 Grey' toting Kh-31P ARMs and assorted AAMs, including red-painted R-77s.

Left: A Su-27P interceptor at Savasleyka AB with a selection of R-27R and R-27T missiles (with pointed and blunt protective caps respectively) arrayed in front of it at Savasleyka AB during an 'open house'.

Below left: The second prototype MiG-29K ('312 Blue') with the wings folded and the Russian Navy's St. Andrew's flag on the fins in the static park of the MAKS-99 airshow. The dummy R-77 and R-73 missiles illustrate well the fighter's small size – an asset during shipboard operations.

Right: This picture from a 1970s Soviet magazine shows a KS-1 under the port wing of a Tu-16KS as a ground crewman checks the connections. The ground handling dolly appears to have been lifted *together with the missile*!

Below: This Indonesian Air Force Tu-16KS serialled M 1625 (c/n 6203427) is on display in Jakarta together with a pair of KS-1s. The shed protects it from the elements but renders good pictures (from a photographer's standpoint – that is, with an unobstructed view) impossible.

Above: A red/yellow chequered development example of the KSR-2 is hooked up to the Tu-16KSR-2 prototype by means of hand-driven hoists. The radome has been detached.

Left: An all-red inert KSR-2

Below: Wasps'R'Us. The two KSR-2s carried by the Tu-16KSR-2 prototype (c/n 7203608/'7124') sport a yellow/black our scheme. The one on the port pylon is missing the dielectric nosecone.

Right: An Egyptian Air Force Tu-16KSR-2 serialled 4404 with two KSR-2s under the wings.

Below and bottom: This Kh-20M is displayed together with the Tu-95KD that carried it at the Long-Range Aviation Museum at Dyaghilevo AB in Ryazan'. Note the Tu-95KD's weapons bay door design and the deployed missile retaining arms.

Left and above: An inert Kh-22M with a PMG active radar seeker head on the BD-45F centreline pylon of a Tu-22M3 at one of the Moscow airshows. These views show well the semi-recessed position of the missile and the folded ventral fin.

Below: A Kh-22M on a ground handling dolly beside a Tu-22M3 at the Long-Range Aviation Museum at Dyaghilevo AB.

Above right: A pair of Tu-22M3s carrying two Kh-22Ms each on the BD-45F wing glove pylons makes a flypast at Kubinka AB on 11th April 1992 with the wings at minimum sweep.

Right: Tu-22M3 '41 Red' with two Kh-22M missiles under the wings in the static park at the display organised for the political and military leaders of the CIS republics at Machoolishchi AB near Minsk on 13th February 1992.

Below right: An inert KSR-5 missile is hooked up to a Tu-16K-10-26.

Left: A Kh-66UD inert training round under the port wing of a MiG-21MF.

Below left: Another view of the same missile, showing the rocket motor nozzles.

Bottom: Appropriately coded '27 White', this Su-24 development aircraft known at the Sukhoi OKB as the T6-27 carries three inert Kh-29L laser-guided missiles under the wing gloves and on the centreline, plus two dummy Kh-23 missiles on the outer wing pylons.

Right. The MiG-23-98 upgrade demonstrator (a converted MiG-23MLD) with an impressive array of weaponry, including (front row) two Kh-25ML laser-guided missiles, a KAB-500T TV-guided bomb and a KAB-500L laser-guided bomb; (centre row) two Kh-29T TV-guided missiles flanked by Kh-31P ARMs and (rear row) R-73, R-77 and R-27R AAMs.

Below right: A pair of Kh-25MLs on a ground handling dolly.

Above: Dummy versions of the radar-homing Kh-25MR (left) and the laser-guided Kh-25ML.

Left. A Kh-25MP passive radar homing anti-radiation missile.

Below: The MiG-27K prototype with an inert Kh-29T under the port wing

Right: A Polish Air Force Su-22M4 with its assorted air-to-ground weapons – Kh-29T missiles foremost, followed by Kh-25MLs, S-24 unguided rockets, UB-32A FFAR pods, KMGU-1 submunitions pods, 250-kg 'iron bombs' and SPPU-22-01 cannon pods.

Above: '501 Blue', the prototype of the Su-30MKK version developed for China (K = *Kitay*, 'China'), carrying red-painted Kh-59Ms on the inboard wing stations, Kh-31As and dummy R-73Es further outboard, RVV0AEs on the centreline and an APK-9 data link/guidance pod under the port engine nacelle.

The sixth and final prototype of the MiG-29M ('156 Blue', c/n 2960905556) carrying four dummy Kh-31As, two dummy Kh-77s and two R-73s.

Above: The second prototype Su-30MKK ('503 Blue') fires a S-25-OFM rocket.

Seen in chrome yellow primer, the third prototype Su-30MKK ('503 Blue') unleashes a Lh-29L missile. Note the deployed airbrake.

Left: Su-34 '47 White outline' pulls up into a loop during an airshow, displaying the Kh-31P ARMs under the engine nacelles and the tandem carriage of a Kh-59M missile and its associated APK-9U guidance pod on the centreline. Note the heat-resistant skin on the outer portions of the stabilators – a precaution against the terrific flames produced by heavy missiles and rockets.

Below: '43 Blue', the first Su-34 in representative production configuration, is shown here with three AFM-L Alpha missiles on the inner wing and centreline pylons, with Kh-331As, R-27Ts and R-73s further outboard.

Above: Su-34 '47 White outline' drops a stick of FAB-250M-54 bombs. The bombs are carried on MBD3-U6-68 multiple ejector racks.

Above: A Su-24M lets loose a heavy unguided rocket (unidentifiable at this angle).

Right: Su-24M '10 White' drops a load of FAB-500ShN parachute-retarded bombs.

Above. The first true prototype of the Su-24 (the T6-2I) fully loaded with 24 FAB-250 bombs on four MBD3-U6-68 MERs, which equals an ordnance load of 7 tons (15,430 lb).

Opposite page, top: Polish Air Force Su-22M4K '3213 Red' fully loaded with FAB-100 bombs. Neither of the four MERs can be loaded with all six possible bombs due to space limitations.

Right: FAB-250M-45 and FAB-500M-54 bombs and S-24 HVARs in front of a Su-25TK carrying B-13L FFAR pods, Kh-39L and Kh-25ML missiles, and Vikhr' ATGMs.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Above: The Sukhoi S-32M development aircraft (the prototype of the production-standard Su-17 fighter-bomber) carrying four UB-32A FFAR pods under the wings and two UPK-23-250 cannon pods under the fuselage.

Left: A MiG-29SE with a selection of weapons, including B-8M1 FFAR pods foremost, KMGU-1 pods interspersed with drop tanks, and FAB-250M-62 bombs.

Below: B-8V7 and B-8M1 FFAR pods, a UPK-23-250 cannon pod, AAMs and high-and low-drag bombs in front of MiG-29SMT '918 White' (c/n 2960536050) at the MAKS-2003 airshow. A Kh-35 air-to-surface missile is visible on the right.

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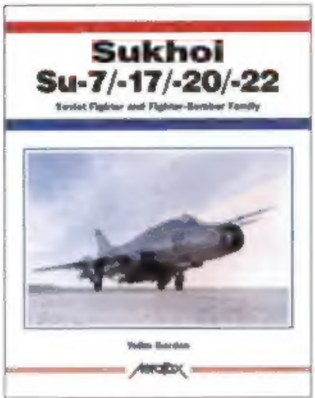

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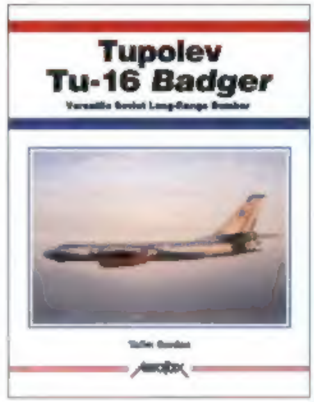

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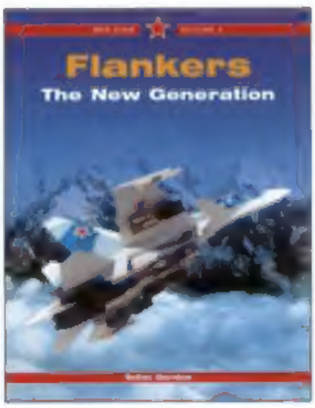

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